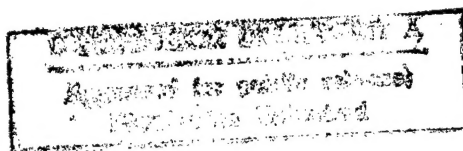


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4 August 1982



China Report

ECONOMIC AFFAIRS

No. 254

ENERGY: STATUS AND DEVELOPMENT. -- VII

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NATIONAL POLICY

IMPORTANT POLICY FOR FUEL MANAGEMENT

Beijing WUZI GUANLI [MATERIALS MANAGEMENT] in Chinese No 2, 1982 p 10

[Article by Commentator: "An Important Policy for Fuel Management"]

[Text] Document No. 51 issued by the State Council in 1981 regarding the offer of incentives for conserving energy and the raising of prices for fuel consumption above the quota represents an important policy for strengthening the control of energy consumption. The Ministry of Finance, the State Labor Bureau and the State Supplies Bureau had in 1979 issued provisions offering incentives for fuel conservation on a trial basis. Document No. 51 issued by the State Council calls upon the various regions and departments to formulate detailed measures for energy conservation on the basis of their actual experiences. Recently, the State Planning Commission, the State Economic Commission, the State Energy Commission, the Ministry of Finance, the State Price Control Bureau and the State Supplies Bureau jointly issued the "Enforcement of provisions for increased charges for fuel consumption exceeding the quota" to put into effect the important policy of the State Council regarding the control of fuel consumption. This is a policy which the various regions, departments and enterprises should seek to implement in a positive manner.

Fuel constitutes a weak link in the development of the economy at the present time. Whether our national economy can be developed at a more rapid pace and whether there can be a new breakthrough in its development depends to a large extent on whether the problem of fuel supply and distribution can be properly solved. "The placing of equal emphasis on the development of energy resources and the conservation of energy, the giving of a higher priority to energy conservation for the time being, the making of technical improvements and structural reorganizations in order to conserve energy" constitutes an important policy of the Party Central Committee and the State Council on the question of energy resources and a strategic measure for the implementation of the four modernizations.

In the implementation and enforcement of the energy policy of placing equal emphasis on developing new resources and on energy conservation and of giving a higher priority to conservation in the meantime, many regions, departments and enterprises have, in the management of fuel consumption in recent years in line with the "Measures for the unified control of fuel and the fuel rationing system" handed down by the State Council, undertaken the work of setting quotas

for fuel consumption and of the rationing of fuel by issuing coupons, put in order the distribution of fuel, strengthened the control of fuel consumption and started an energy conservation movement. According to an analysis made by the State Statistical Bureau, 13 million out of the 35 million tons of standard coal conserved throughout the nation in 1980 was due to strengthened control over fuel consumption. Since 1980, 111 large and medium-sized cities throughout the nation have launched energy conservation contests. The localities and the enterprises in these cities have without exception set a quota for fuel consumption, adopted the rationing system and reduced the rate of consumption by checking the actual consumption against the set quotas. In 1980, the value of the local industrial output in 51 cities such as Shanghai, Tianjin and Guangzhou showed an increase of 8.5 percent while fuel consumption was reduced by 3.2 percent. The amount of 5.74 million tons of coal was saved during the year. According to statistics supplied by 30 cities, the value of the local industrial output for the first half of 1981 showed an increase of 4.89 percent compared to the same period of the previous year while fuel consumption was reduced by 5.59 percent. Facts have proved that control over fuel consumption is an important way to conserve energy. The problem is that measures for fuel conservation have yet to be effectively implemented by all the parties concerned. The need to "ensure the supply of fuel by exercising control over its consumption" has yet to be generally appreciated and the waste of energy remains a serious problem.

In exercising control over the consumption of fuel, it is of paramount importance to further reduce energy consumption and to utilize energy to better effect. It is necessary to adopt effective measures to set a stringent quota for fuel consumption for the various types of production engaged in by the workshops, the work teams and the furnaces. A system should be established to watch over the production teams and to make every worker individually responsible for contributing his share toward fuel conservation as a matter of routine. The actual amount of consumption must be checked against the set quota. Citations should be given for reduced fuel consumption while an extra charge should be made for fuel consumption above the quota. In order to induce the enterprises to take advantage of their experiences, to adopt improved methods and to do their part to conserve energy without delay, it is absolutely necessary to give rewards and to mete out punishment where they are due. In 1980, The Shanghai Fuel Company was the first to put into effect on a trial basis the system of charging higher rates for fuel consumption above the quota with encouraging results. In the second quarter of that year, 63 factories in the city exceeded the quota in the consumption of fuel. After the adoption of the system in the third quarter, 41 out of that number stayed within the limit of the quota. In the first quarter of 1981, 114 units in the city paid higher rates for exceeding the quota. In the second quarter, 83 out of that number managed to stay within the limit. In the process of charging higher rates, the Fushun Fuel Company, after having checked and rechecked the amounts of fuel consumption over and above the quota, was able to pinpoint the contributory factors. The enterprises, thoroughly convinced, proceeded to reduce the rate of fuel consumption. In the third quarter of 1981, the fuel consumption by 205, or 83.7 percent, of the 240 major productive enterprises in the city reached or fell below the lowest level in fuel consumption in their history. Actual experience has proved that increased

charges for fuel consumption over and above the quota is an effective way to strengthen the control of the fuel consumption quota system, to encourage the enterprises to conserve and to make the best use of energy and that it is the correct policy for the control of energy consumption to resort to both administrative sanctions and economic measures. The implementation of this policy will serve to further promote the positive attitude on the part of the enterprises to strengthen their control over energy consumption, to explore all the potentials, to conserve the use of energy and to achieve greater economic benefits. It is incumbent upon the fuel supply departments at various levels to pursue this line of work in a positive manner, to strengthen their control over fuel consumption and to verify the amount of fuel consumption on an annual basis. In addition to increasing charges for fuel consumption over and above the quota according to stipulations, they must, in consultation with the concerned enterprises, seek to pinpoint the reasons for the high rate of consumption on the basis of actual facts and to help them to find a solution to the problem.

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CSO: 4013/52

NATIONAL POLICY

MEASURES FOR IMPLEMENTATION OF PRICE INCREASES FOR ABOVE-QUOTA FUEL CONSUMPTION

Beijing WUZI GUANLI [MATERIALS MANAGEMENT] in Chinese No 2, 1982 pp 11-12

[Text] State Planning Commission, State Economic Commission, State Energy Commission, Ministry of Finance, State Price Control Bureau, State Supplies Bureau

Notification regarding the publication of "Measures for the Implementation of Price Increases for Fuel Consumption Above the Quota"

The Provinces, Municipalities, Economic Commissions, Bureaus of Finance (Departments), Energy Conservation Offices, Ministries, Commissions and Bureaus under the State Council, Ministry of Logistics, Scientific Commissions for National Defense, Railway Corps, Engineers Corps:

Document (1981) No. 51 issued by the State Council concerning price increases for the consumption of energy by the enterprises above the quota is an important policy of the state for energy control. For the enforcement of this policy, the "Measures for the implementation of price increases for fuel consumption above the quota" is hereby issued to you with the request that it be implemented forthwith.

(20 November 1981)

Measures for the implementation of price increases for fuel consumption above the quota

(November 1981)

1. These measures were specifically formulated in accordance with Document (1981) No. 51 issued by the State Council "regarding stipulations for levying increased charges for energy consumption above the quota by the enterprises, and the increased charges are to be used mainly for energy conservation projects" and in the light of the actual experiences of certain localities in the implementation of the decision by the State Economic Commission and the State Planning Commission to raise prices by 50 percent for fuel consumption above the quota.

2. These measures are to apply to enterprises with an annual consumption of over 300-600 tons of coal (150-300 tons of fuel oil or 200,000-350,000 cubic meters of natural gas) and whose energy consumption quotas are subject to review.

3. The enterprises must, on the basis of their best record for fuel consumption in history and the existing technical productive circumstances, set a quota for fuel consumption according to the nature of their products (or according to the amount of the major raw materials or according to the production value, the number of furnaces and plants). Those enterprises which have already reached the advanced level of enterprises in the same line of business must consolidate and improve upon their gains. Those enterprises which have adopted major fuel conservation measures must set up proper quotas on the basis of the results after the fuel conservation measures have been put into effect. Those enterprises which set the quota on the basis of the value of their products must take into account changes in the makeup of their products in drawing up the quota.

The fuel consumption quota for the enterprises is to be reviewed annually. The procedure is as follows: The concerned authorities of the various state enterprises responsible for the supply of fuel and the State Supplies Bureau are to submit the quotas agreed upon to the State Economic Commission for its approval. The concerned authorities of the enterprises in the localities and the fuel companies responsible for the direct supply of fuel to the enterprises are to submit the quotas agreed upon to the economic commission of the same level for its approval.

The amount of fuel supplied to the enterprises is to be determined on the priority system by the concerned authorities of the enterprises and the fuel supply departments on the basis of the approved production target and in accordance with the plan for the allocation of fuel and the fuel consumption quota.

4. To strengthen control over fuel consumption, the various enterprises are to equip themselves with fuel gauges and meters so that they may have a record of the amount of fuel consumption and that they may review the implementation of the quota system on a monthly or quarterly basis.

5. The amount of fuel allocated to the various enterprises is to be based on their original record of consumption, including supplies from various sources, adjusted supplies and supplies provided by other enterprises through mutual agreement. An additional 50 percent is to be charged for any amount in excess of the quota on top of the average amount presently charged for the same type of fuel by the fuel supply departments. The increased charges for fuel consumption above the quota are to be assessed on a monthly or quarterly basis. The increased charges are to be paid first. Accounts are to be settled annually. The amount overcharged is to be returned and the amount outstanding is to be repaid. The amount of surcharge may be reduced according to circumstances if the fuel consumption above the quota is due to differences in the quality of the products put out by the enterprises and differences in the quality of the coal supplied to the enterprises.

6. As a matter of principle, the surcharge for fuel consumption above the quota should be used to subsidize the cost of energy conservation projects. Forty percent of the surcharge is to be paid to and allocated by the financial departments while 60 percent is to be retained and administered as a special item by the units to which the surcharges are paid. The funds may be used only for energy conservation and for no other projects.

The fuel companies which deliver fuel supplies directly to the local enterprises are to be responsible for verifying and receiving surcharges for fuel consumption above the quota. Forty percent of the surcharge is to be listed as income beyond the operations of the companies and paid to the local financial departments on the conservation department or the economic commission on the same level to be used at its discretion. The fuel companies are to be responsible for using the special funds for energy conservation and for no other purpose.

As for the enterprises of the various departments on the state level responsible for the supply of fuel, the responsible departments are, as a matter of principle, to be responsible for the verification and receipt of the surcharges for fuel consumption above the quota. Forty percent of the amount is to be listed as extraordinary income of the department concerned and paid to the financial authorities of the state while 60 percent is to be retained and to be used for energy conservation purposes by the departments concerned. The various departments are to formulate a set of rules for the settlement and management of accounts according to actual circumstances.

7. The surcharges levied against the various enterprises for fuel consumption above the quota are to be paid out of the production development fund of the foundation fund or the profit retention fund of the enterprises. The outstanding amount, if any, is to be paid out of the renewal and rebuilding fund and is not to be listed as production costs.

8. These measures are to become effective on the date of their approval and promulgation and will be operative as from January, 1982. The provinces, municipalities, autonomous regions, ministries of the State Council, commissions and bureaus are to formulate bylaws for their implementation according to existing circumstances and to submit reports to the State Economic Commission, the Ministry of Finance and the State Supplies Bureau for the record.

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CSO: 4013/52

NEW TECHNOLOGY

MHD POWER GENERATION AND SUPERCONDUCTOR TECHNOLOGY

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese, No 1, 15 Feb 82, pp 36-42

[Article by the New Electricity Generation Technology Research Laboratory of the Shanghai Power Generation Equipment Design Research Institute: "Magneto-hydrodynamic Power Generation and Superconductor Technology"]

[Text] [Abstract]

This article describes the development in electrical engineering and the new problems that have emerged. The article talks about the principles, advantages and present development in magneto-hydrodynamic power generation and superconductor technology and analyzes the development of key technologies of magneto-hydrodynamic power generation and superconductors and their prospects.

I. Foreword

As modern industry has rapidly developed, the consumption of electricity has increased rapidly over the past decades. Even though the installed capacity of power stations and the capacity of the largest single generator have increased continually each year at a growth rate of 10 percent, they still cannot satisfy the needs of development of human society. In power generation facilities, the total installed capacity of the world's generators at present has reached 1.5 billion kilowatts. The largest single generator capacity has reached 1.3 million kilowatts. The highest cyclic thermal efficiency of power stations has reached 39.8 percent. According to estimates, by the year 2000, the total installed capacity of power generators will reach 8 billion kilowatts, and requirements for single generators with a capacity of 3 million to 5 million kilowatts may be proposed. From the point of view of nonrenewable energy resources, obviously we hope to increase the thermo-electric conversion efficiency of current equipment greatly to conserve the nonrenewable resources that are becoming more and more precious. In the ordinary development of electrical engineering technology, the cooling techniques, the levels of insulation, and the capacity of the single generator of ordinary generators have developed greatly since the successful test run of the first generator with a candle power of 600 in the world in 1882, and the technology has been

highly perfected. The capacity of large single power generators has approached "saturation", and has begun to reach the "capacity limit." This is because the capacity P of a generator is limited and determined by the following factors:

$$P \approx nDLAB$$

where n is limited by the operating frequency of 50 cycles/second (or 60 cycles/second). The diameter D of the rotor and the length L of the forgings are limited by the mechanical strength, the critical speed of rotation and vibration. The load A of the power lines is limited by the armature winding current density. The magnetic flux density B is limited by the density of the magnetic field and the iron core magnetic saturation. Judging from the currently available technical levels, the capacity of the ordinary large single generator will reach its "limiting capacity" when it reaches 2 million kilowatts. Continued increase in capacity will encounter difficulties that will be difficult to overcome.

The thermo-electric conversion efficiency of current ordinary thermal power generation equipment is usually only about 30 percent to 40 percent. To improve thermal efficiency, the present thermal power generation equipment has used large capacity, high parameter and intermediate reheating techniques, but its highest thermal efficiency can only approach 40 percent. This is because the thermal efficiency of the ideal Carnot cycle:

$$\eta = \frac{T_1 - T_2}{T_1}$$

The thermo-electric conversion efficiency is mainly determined by the initial temperature T_1 and the final temperature T_2 of the work mass of the cycle in which T_2 is limited by the temperature of the environment, and the initial temperature T_1 is limited by the heat tolerance of the high speed rotary steam turbine and the strength of materials. At present, they can only reach about 565°C. To further improve the thermal efficiency of current thermal power generation, the initial temperature of the cycle must be greatly increased, and this will bring about extreme difficulties for the high speed rotating steam turbine. Therefore, analysis based on present technology indicates that an efficiency of 40 percent will be the "limiting thermal efficiency" of ordinary thermal power generators. This means, for every 100 kilograms of fuel, only 40 kilograms are converted into electrical energy, and the remaining 60 kilograms are all converted to various types of waste heat and are wasted. This will be a heavy task for the production, supply and transport of exhaustible energy resources.

Therefore, even though electrical engineering technology has realized very great achievements during the past 100 years and more, as the need for electric power by mankind increases, a series of new demands and new topics by mankind increases, a series of new demands and new topics which must be studied will emerge to challenge electrical engineering technology. Magneto-hydro-dynamic power generation and superconductor technology are new electrical engineering technologies that have rapidly developed against this background.

II. The Principles, Characteristics and Present Development of Magneto-hydrodynamic Power Generation and Superconductor Technology

1. Magneto-hydrodynamic Power Generation

(1) The principle of magneto-hydrodynamic power generation originated from the English "magneto-hydrodynamic power generation", abbreviated MHD, or the generation of electricity by magneto-hydrodynamics. The principle of magneto-hydrodynamic generation of electricity is very simple. It involves the use of a high temperature electrically conducting fluid which passes through and cuts across magnetic lines of force of a magnetic field to produce inductive electrodynamic potential. When a load is connected to a closed circle, we have a new method of generating an output of electrical energy.

Present thermal power generation consists of boilers, steam turbines and generators. Fuel burns in the boiler to heat water and produce steam. The steam drives the steam turbine. The steam turbine then drives the generator to produce electricity. The method involves two energy conversions. Thermal energy is first converted to mechanical energy. Then the mechanical energy is converted to electrical energy. Therefore the system is complex, the structure is huge, the initial temperature of the thermal cycle is low and the efficiency of energy conversion is low.

Different from the present method of thermal power generation, the magneto-hydrodynamic generation of electricity is a new method of generating electricity by directly converting thermal energy into electrical energy. It eliminates intermediate conversion into mechanical energy, therefore it has many outstanding advantages.

(2) Advantages of magneto-hydrodynamic generation of electricity

When the magneto-hydrodynamic electricity generator is used alone, its structure is compact, its system is simple, its size is small, processing is easy, its construction cost is low (about 1/4 the cost of ordinary thermal power generation equipment), its starting time (full power of several 10,000 kilowatts can be reached within several dozen seconds) is rapid, and it is especially suitable for use as a special purpose test power source and peak load power station.

Figure 1 shows a stand-alone magneto-hydrodynamic power generation developed successfully by us in 1972.

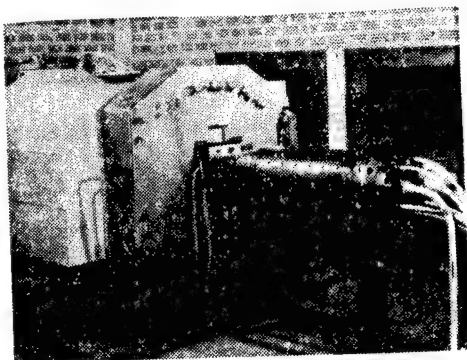


Figure 1. The 580-kilowatt short interval magneto-hydrodynamic power generator [with maximum power of 580 kilowatts (3,360 amperes at 175 volts) which operates for 3-minute intervals]

When the magneto-hydrodynamic power generating equipment joins regular steam driven devices in a joint cycle, the 2000°K high temperature fuel gas released by the magneto-hydrodynamic power generator can be fed into the surplus heat boiler to produce steam for generating electricity again. In such a joint cycle of magneto-hydrodynamic and steam power, the thermal energy of the fuel is utilized twice to generate electricity. The total thermal efficiency of the joint cycle is expressed by the following formula:

$$\eta = \eta_{\text{MHD}} + \eta_{\text{ST}} (1 - \eta_{\text{MHD}})$$

η_{MHD} is the cyclic efficiency of magneto-hydrodynamic power generation, generally reaching 20 percent to 30 percent.

η_{ST} is the cyclic efficiency of ordinary thermal power generation, generally reaching 30 percent to 40 percent.

When $\eta_{\text{MHD}} = 20$ percent, $\eta_{\text{ST}} = 40$ percent, $\eta = 52$ percent.

$\eta_{\text{MHD}} = 30$ percent, $\eta_{\text{ST}} = 40$ percent, $\eta = 58$ percent.

It can be seen that using the new technique of magneto-hydrodynamic power generation can increase the thermal efficiency of ordinary thermal power generation from 30 and 40 percent to 50 percent and 60 percent, equivalent to a conservation of 1/4 to 1/3 of fuel. When a joint 1 million kilowatt magneto-hydrodynamic and steam powered cycle with a 60 percent efficiency is compared to a regular thermal power station with 40 percent efficiency, 1 million tons of fuel can be conserved a year. Also the efficiency has been improved, and the amount of waste heat at the release exit is only about one half that of ordinary power stations. This greatly reduces heat pollution of the environment. At the same time, because a small amount of alkaline electrically conducting medium is added to the magneto-hydrodynamic power generating process, easily retrievable and usable sulphates formed by sulphides in the fuel are easily formed. This can greatly reduce "sulfur pollution" by present thermal power generation equipment.

Therefore, joint magneto-hydrodynamic and steam power stations that have a high efficiency and that produces little pollution have become a fundamental change in the method of power generation and have become an important direction in the development of present thermal electricity generation techniques.

Figure 2 shows a simulated generator of a small joint magneto-hydrodynamic and steam power station we developed successfully in 1976.

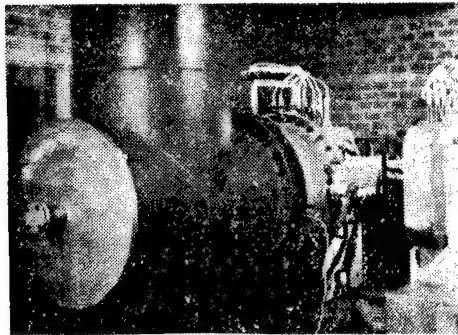


Figure 2. An 18-kilowatt long interval magneto-hydrodynamic power generator (with maximum power of 18 kilowatts, continuous operation of 200 hours).

(3) The Present Development of Magneto-hydrodynamic Power Generation

The United States was the first in the world to use the magneto-hydrodynamic power generation method to light 228 50-watt bulbs in 1959. Since then, over a dozen nations including the Soviet Union, the United States, Japan, India and Romania have invested a lot of manpower and materials in research and they have greatly emphasized it and developed it as a policy of national technological development. Since the 1970s, technical progress has been realized and magneto-hydrodynamic power units have achieved the level for industrial tests. The Y-25 joint magneto-hydrodynamic and steam cycle power station jointly researched by the Soviet Union and the United States (magneto-hydrodynamic power generation of 25,000 kilowatts, steam power generation of 50,000 kilowatts) has been most noteworthy. The Soviet Union has announced plans to build the world's first practical power station with 500,000 kilowatts of power and an efficiency of 50 percent by 1985. The United States and Japan are also planning to rapidly build industrial test equipment of the 10,000-kilowatt class. Although our nation began scientific research as early as the 1960s and built a few experimental generators with several kilowatts of power, several dozen kilowatts of power, and several hundred kilowatts of power with operating intervals of several minutes, several hours, seven dozen hours to 200 hours, as well as a small simulated joint cycle magneto-hydrodynamic and steam power station with a magneto-hydrodynamic power of 9 to 13 kilowatts and a steam power of 500 kilowatts and an operating period of 150 hours of which 100 hours were on-line operation in the power network, basically these were all on a small-scale laboratory and research level. Foreign nations believe that a joint cycle magneto-hydrodynamic power station with a power of 1 million kilowatts and an efficiency of 50 percent will be successful in the 1980s, and by the 1990s, large-scale industrial applications will be realized.

2. Superconductor Technology

(1) Principle of Superconductor Technology

In 1911, a Dutchman named Kamerlingh-Onnes discovered that the electrical resistance of mercury suddenly dissipated to zero under a low temperature of 4.2°K (-269°C). He called this phenomenon superconduction. Those metals,

alloys and compounds that possessed superconducting characteristics under low temperatures were called superconducting materials. The current density of superconducting materials in low temperatures can reach 60,000 to 100,000 amperes/square centimeter, and they can produce magnetic fields of 60,000 to 170,000 gauss. People have used them to develop various kinds of electro-mechanical machinery and equipment. This is the superconductor technology that has developed prosperously during the past dozen years.

Superconducting materials generally have three characteristic quantities: the critical temperature T_c when superconductivity appears; the maximum current density under the critical temperature -- critical current density J_c ; and the maximum magnetic field intensity under this condition -- the critical magnetic field intensity H_c . When any one of the characteristic quantities above is surpassed, the superconducting material immediately loses its superconducting characteristics, described as a "loss of superconduction phenomenon", and electrical resistance rapidly emerges. The critical characteristics of typical superconducting materials presently available are listed in the following table:

The most widely used is the Nb-Ti alloy and Nb₃Sn compound. The goal that is continually being sought by physicists and metallurgists is to maximize the critical temperature, critical current density and critical magnetic field intensity of superconducting materials.

Materials	T_c (°K)	H_c (kilogauss)	J_c (ampere/square centimeter)
Nb-Ti	9.3	120	-- 1.5×10^5
Nb-Zr	10.8	75	
V ₃ Ga	16.8	210	
Nb ₃ Sn	18.1	245	3×10^5
Nb ₃ Ge	23.2	350	

(2) Advantages of Superconductor Technology

Under low temperatures, the electrical resistance of superconducting materials is "zero". At the same time, the materials can bear a very high current density. If the current density of a water cooled copper lead wire is 1,000 amperes/square centimeter, then the current density of superconducting materials is almost 7 to 10×10^5 amperes/square centimeter. Also, when a superconducting material conducts electricity, almost no heat loss occurs. At the same time, it can produce a strong magnetic field of 100,000 gauss without any iron magnet (therefore it is not limited by iron core magnetic saturation). Thus, electric

motors, electrical devices and magnets made of superconducting materials have a string of outstanding technical advantages such as light weight, small size and high efficiency. When comparing a superconducting generator and an ordinary generator, the following advantages are obvious:

(1) The air gap magnetic density B of a superconductor generator can be increased from 8,000 gauss of ordinary generators to 40,000 to 50,000 gauss. The load A on the line of the armature winding can use a troughless structure which will increase it by onefold. In this way, and after estimating some other factors, the theoretical capacity limit of a superconductor generator can be increased from 2 million kilowatts of ordinary generators to 10 million kilowatts or more.

(2) The outer diameter D and length L of the rotor of a superconductor generator are 0.8 to 1.0 and 0.4 to 0.6 that of ordinary generators. The superconductor generator will be visibly smaller.

(3) The weight of the rotor of a superconductor generator is only $1/4$ to $1/3$ that of an ordinary generator. The weight of the whole machine is $1/3$ to $1/2$ that of an ordinary generator, and the superconductor generator will be visibly lighter.

(4) The wear on copper of the rotor of a superconductor generator is almost zero. Loss due to mechanical wear will be reduced to $1/3$, and total loss will be reduced to $1/2$. In a bipolar generator, the efficiency can be increased by 0.5 percent to 0.8 percent, and the efficiency of a quadrupolar generator can be increased by 0.3 percent to 0.5 percent.

(5) Since the superconductor generator uses a non-magnetic rotor and an air gap armature winding, synchronous electrical impedance is reduced to $1/4$, its operating stability will visibly improve.

(6) Because future superconductor generators can almost completely eliminate the iron core, the electrical insulation of the armature can be greatly improved. This makes it possible to manufacture high voltage generators that can be connected directly to the power network in operation. Thus, step up transformers necessary to ordinary generators can be eliminated.

(3) The present development of superconductor technology

The above advantages enable superconductor technology to be broadly used in almost all realms of electrical engineering. Superconductors are necessary in magnetically confined magnets of controlled thermonuclear reactors in the future, they are necessary for generating strong magnetic fields of high energy accelerators, and they are necessary in building strong magnets for magneto-hydrodynamic generators. Superconductor generators also have very broad uses and a broad future for development. At present, foreign nations have already successfully developed synchronous superconductor generators of 6,250 kilovolt-amperes, 5,000 kilovolt-amperes and 2,000 kilovolt-amperes. Westinghouse of the United States is developing the world's first practical superconductor generator of 300,000 kilovolt-amperes. It is expected to

begin operation in 1983. Strong superconductor magnets for large high energy accelerators and strong superconductor magnets for magneto-hydrodynamic power generation have already begun operation. Small superconductor magnets used massively in scientific experiment and precision instruments have already been commercialized. Many 10,000-kilowatt class superconductor generators and large superconductor magnets for controlled thermonuclear reaction are being developed. A lot of effort is being exerted to develop, explore and study magnetically suspended high speed trains using superconductors, mineral selection and separation devices using superconductor magnetic fields, superconducting cables and superconductor energy storage. Since the 1960s, our nation has also developed scientific research in superconductor technology. Now, our nation can produce Nb-Ti, Nb Sn and many other types of superconducting materials. Many small superconductor magnets have already been successfully developed. We have successfully developed a 428-kilovolt-ampere synchronous superconductor generator with a lot of help from sister units. At present, we are conducting scientific research in building a 10,000-kilovolt-ampere class superconductor generator. Foreign nations have generally analyzed the situation and they believe superconductor technology will make major technical breakthroughs in the 1980s, and beginning from the 1990s, superconductor technology will have large scale industrial applications in the realm of electrical engineering. Therefore, some people predict that electrical engineering has begun to enter an era of "superconductor electrical engineering".

Figure 3 shows the exterior of the 428-kilovolt-ampere synchronous superconductor generator we successfully developed and tested in 1977.

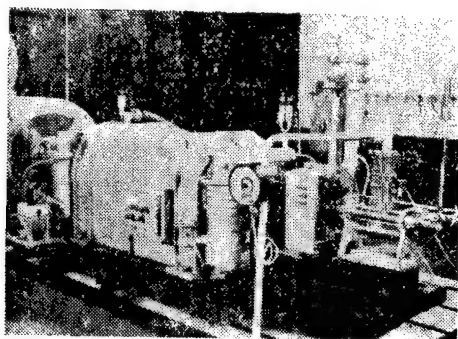


Figure 3. The 428-kilovolt-ampere synchronous superconductor generator

III. Key Technologies That Must Be Solved in Magneto-hydrodynamic Power Generation and Superconductor Technology

Magneto-hydrodynamic power generation and superconductor technology are two new electrical engineering technologies that have developed rapidly during the recently 20 years. They not only follow the laws of ordinary electrical engineering technology, their development is closely related to the so-called "technologies of limits", ultrahigh temperature technology and superlow temperature technology. Therefore, there is a series of new demands and new subjects which require the use of new materials and a series of new structures.

1. The key technologies of magneto-hydrodynamic power generation

Magneto-hydrodynamic power generation is a new type of power generating facility which utilizes high temperature ionic gases passing through a strong magnetic field to produce electrical energy. Its output power is determined by the following formula:

$$P \approx \sigma K(1 - K)B^2 u^2$$

where σ is the electrical conductivity of the high temperature gas, B is the magnetic flux density, u is the speed of flow of the high temperature electrically conducting gas, K is the load coefficient determined by the internal electrical resistance and the external load of the magneto-hydrodynamic power generating facility.

It can be seen from the above that when the speed of flow and the load coefficient are fixed, the greater the electrical conductivity σ and the magnetic flux density B , the greater the power of the magneto-hydrodynamic power generator and the greater the thermoelectric conversion efficiency. The electrical conductivity σ of the high temperature gas and temperature are closely related:

$$\sigma = 0.81 \left(\frac{T}{2000} \right)^{12} P^{-0.57}$$

To assure that the thermoelectric conversion efficiency of η of magneto-hydrodynamic power generation reaches above 20 percent, the electrical conductivity σ must reach 5 to 10 ohms/meter. This requires the temperature of combustion to reach above 3,000° K while the intensity of the magnetic field B must reach 50,000 to 60,000 gauss. Therefore, magneto-hydrodynamic power generation must solve the following key technologies:

(1) Ionization technology of high temperature gases

We must make sure that the operating mass for magneto-hydrodynamic power generation must have maximum electrical conductivity, therefore, we must solve a series of basic theoretical problems in plasma physics and thermoelectric physics related to the ionization characteristics of gases to guarantee that under an operationally feasible high temperature of 3,000°K, the gas can undergo maximum ionization.

(2) Study of new materials tolerant to high temperatures

To make sure that the magneto-hydrodynamic generator can operate for a long period under a high temperature of 3,000°K and a high speed of gas flow of 1,000 meters/second, we must have electrically conducting materials and insulating materials that can perform under such conditions. Now, high temperature resistant zirconium dioxide procelain is generally used as electrodes and magnesium oxide procelain is used as an insulating material. But their useful life lasts only several hundred hours. This is far from the requirements for long-term operation of 2,000 to 5,000 hours.

(3) Strong Superconductive Magnetic Field Technology

To guarantee a high efficiency in magneto-hydrodynamic power generation, we must use large and strong superconductive magnets of 50,000 to 60,000 gauss. This itself presents a series of new technological problems.

(4) Magneto-hydrodynamic power generation can only generate direct current electricity at present. To enable it to operate within a power network environment, the technology of large power direct current-alternating current inversion must be solved and there must be effective zero-work compensation.

(5) The auxiliary system for magneto-hydrodynamic power generation: high temperature air preheater and technology of retrieval and utilization of additives.

2. Key superconductor technology

Because presently available magnetically conducting materials possess "superconductive characteristics" only in superlow temperatures, a series of new technological problems will be encountered when developing superconductor power generators and other strong superconducting magnets. Also, presently available superconducting materials can only carry direct current loads and they cannot carry alternating current loads. Therefore, they can only be used in windings of magnetic fields carrying direct current. At present, applied research in superconducting technology must solve the following key technologies:

(1) The design and winding of the superconductive magnetic field coils.

The design of all superconducting coils requires a magnetic field with an intensity of over 50,000 gauss. The corresponding current density must be 60,000 to 100,000 amperes/square centimeter. Winding of the coil must be easy, and more importantly, the superconducting coil must retain its superconducting state in a stable manner under external interference by various types of electrical magnets, machinery and thermal forces. This means that the electromagnetic fields, the stress field and the thermal field of the superconducting coil must be accurately calculated and designed.

(2) Cooling and supports for superconducting coils

Because the intensity of the magnetic field of the superconducting coil is very strong and the density of the electrical current is large, therefore the electromagnetic force produced is also very large. An effective supporting structure must be provided. Also, because the superconducting coil operates under low temperatures, therefore effective cooling of such coils has very important significance. Especially in a superconducting power generator with a rotary magnetic field coil, a wholly forged rotor cannot be used. A rotor consisting of multiple layers of thin walled tubes must be used. There must be effective support and compensation for the centrifugal force, the electromagnetic force, and the cold contraction force of the magnetic field coil. Also, cooling techniques of liquid that is continuously injected under high speed rotation for deep freezing must be solved.

(3) To guarantee stable operation of superconductive coils under low temperatures, external influence must be reduced to the minimum, and in particular, infiltration of external heat must be prevented. This is an important condition for the stable operation of the superconducting coil. For this, we must guarantee that there is a high vacuum heat insulating layer of 10 to 10 torr between the superconducting winding and the external environment. For the superconducting power generator, we must also make sure that it can maintain the above degree of vacuum under high speed rotation.

(4) To guarantee safe operation of the superconducting coil, we must solve the problems in detecting the "loss of superconductivity" of the superconducting coil and develop corresponding protective measures.

(5) The superconducting coil must operate under low temperatures. Therefore, we must have corresponding cooling equipment. The reliable operation of the refrigerator is also a necessary condition for the safe operation of the superconducting coil.

IV. Outlook

Magneto-hydrodynamic power generation and superconductor technology are two new technologies of electrical engineering that are being developed. Because their technical advantages are outstanding and attractive, they have a strong chance for survival. But, because of their close relationship with the development of modern science and technology, they are also technically very difficult. As electrical engineering technology develops, it will eventually surpass the original field of electromagnetism. The comprehensive development of electrophysics, thermal physics, plasma physics, low temperature superconductor physics is a strong force that promotes the development of electrical engineering technology. Electrical engineering is a branch of science that has developed early. Since, man recognized and began utilizing electromagnetism, a lot of work has been done in the development of electrical engineering technology. Electrical engineering has already made great contributions to human social progress. But, as modern science and technology and social productivity continue to develop, electrical engineering is also undergoing change. The progressively larger power systems and generating equipment, the emergence of new power generating techniques and new power transmission techniques have continued to enlarge the scope of application of electric power. As magneto-hydrodynamic power generation and superconductor technology progress and are broadly applied, a new situation in electrical engineering technology will emerge to make even greater contributions to the development of human society.

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CSO: 4013/28

NEW TECHNOLOGY

EXPERIMENTAL STUDY OF COM IN OIL-FIRED BOILER

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese, No 1, 1982, pp 21-26

[Article by Lin Hao [2651 3493] and Zhou Wenhua [0719 2429 5478] of Qinghua University: "Experimental Study of an Oil-fired Boiler Using Coal and Oil Mixture (COM)"]

[Text] I. Preparation and Storage of Fuel of Coal and Oil Mixture

Preparation of the fuel of coal and oil mixture should be based on the characteristics of our nation's consumption of coal for power production and the use of residual oil as boiler fuel and combined with the actual conditions in production in selecting a plan. At the same time, consideration must be given to the requirements for short term storage and short distance transportation.

1. Our nation uses many types of coal for power production. The quality of the types of coal is poor. Among the 30 major types of coal for power production, there is anthracite with only a 4.30 percent content of combustible base volatile fraction, there is also lignite with a 56.89 percent content of combustible base volatile fraction, and there are 16 types with an analytic base ash content above 30 percent. In fuels of coal and oil mixtures, powdered coal is in the solid dispersion phase in liquid dissociated substances. The size of the granules of powdered coal is not the same. The shape is irregular, and there are many types of structures on the surface. It is generally believed that the coal with a relatively mild degree of coalification possesses more polarized functional groups and has an earlier affinity to water. Actually, this is not necessarily so. The influence of the ash content on the surface of powdered coal is very great. Figure 1 shows the relationship between the affinity of Datong coal to water and the ash content. On the other hand, the weight of Datong coal increases and the content of ash increases. The results are shown in Table 1. In fuel of coal and oil mixtures, heavier coal granules of the same size settle faster. When the surface of the granule has an adsorptive layer, the granules attract each other. The adsorptive layer binds the granules and causes the granules to lose their freedom. At this time, the forces produced to restore the freedom of the granules prevent the granules from coalescing. This is called the entropy effect of the adsorptive layer. Therefore, the affinity to oil of powdered coal is an important property to prevent granules from settling. When the properties of coal and oil do not match, a feasible method is to use a surface activation agent to improve the affinity between coal and oil.

2. Our nation's boiler fuel is crude oil and residual oil. Their wax content and their solidification points are both higher than similar oil products of foreign nations. The solidification points of petroleum and its products in a certain sense indicate their paraffin content. The presence of colloids affects solidification of petroleum and also hinders precipitation of paraffins. In fuel oil, because of condensation, the contents of asphalt and colloids increase and cause the solidification point to rise. Petroleum fractions change from light to heavy and viscosity increases. When using our nation's crude oil or residual oil to prepare mixed fuel, we should fully utilize their characteristic of a high solidification point and a high viscosity to solve the problem of sedimentation of powdered coal. Table 2 lists information on some foreign and domestic crude oils and fuel oils for comparison.

3. According to the sedimentation experiment of presently available mixture of powdered bituminous coal and the mixed fuel of Wuqiu residual oil, we can see that the influence of temperature is outstanding. At the beginning, sedimentation is quick. After a definite period, sedimentation gradually slows down and then it remains unchanged. This is the combined result of coalescence of powdered coal and sedimentation. After two weeks of storage, stirring the mixture again showed that redispersion after this fuel of coal and oil mixture had deposited was good.

4. According to the fineness of powdered coal commonly used in our nation and the performance of solid and liquid mixers of the chemical industry, the combined operating power and wear of the equipment shown after test-operation indicated that the system in Figure 2 [not reproducible] is feasible. This system uses a variable speed drive and regulator to reduce power loss and wear of the equipment. The heater is installed at the outlet of the transport pump to reduce drag. The system is laid out in a plane to facilitate operation and maintenance.

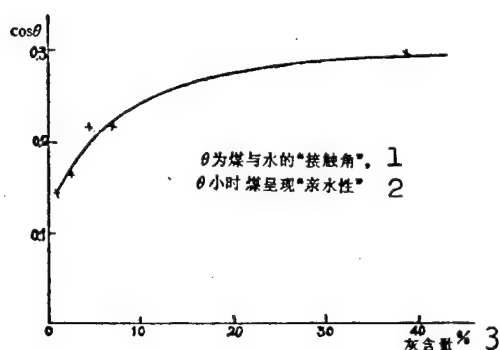


Figure 1. Ash content and contact angle of Datong coal

Key:

1. θ is the "contact angle" of coal and water
2. When θ is small, coal shows "affinity to water"
3. Ash content

Table 1. Relationship Between Weight and Ash of Datong Coal

Item		Weight	<1.25	1.25~1.30	1.30~1.35	1.35~1.40	>1.40
Air dried moisture content			3.46	2.04	1.71	1.84	1.22
Industrial Analysis	moisture content %		5.0	4.2	3.7	4.0	2.7
	ash content %		1.6	2.7	4.6	7.4	39.8
	volatile content %		34.7	31.6	26.6	22.4	19.0
	fixed carbon %		58.7	61.5	65.1	66.2	38.5

Table 2. Partial information on crude oils and fuel oils

7) 序号	8) 名称	9) 重量 吨/米 ³	10) 闪点 °C	11) 凝点 °C	12) 水分 %	13) 灰分 %	14) 低位发热量 Q _H ^P 大卡/公斤	15) 粘度	16) 备注
1	大庆原油	0.8615	38	23~29	0.03	0.02	~10300	E ₈₀ 1.6~2.0	含蜡量28.7% 18)
2	科威特原油	0.8648		-45	0.23			50°C 7.9厘沱	沥青质0.98% 19)
3	伊朗原油	0.8518		-20				30°C 6.8厘沱	含蜡量 2.8% 18)
4	大庆燃料油	0.9326	339	33	0.03	0.017	10080	E ₁₀₀ 5~20	
5	胜利燃料油	0.93~0.96	180~210	25~40		0.01~0.1	9700~9800		
6	东炼燃料油	0.9259					10036	E ₈₀ 30.2	

Key:

- | | |
|---------------------------|---|
| 1. Daqing crude oil | 11. Solidification point |
| 2. Kuwait crude oil | 12. Moisture content |
| 3. Iran crude oil | 13. Ash content |
| 4. Daqing fuel oil | 14. Low heat emission Q _H ^P kilocalorie/- |
| 5. Shengli fuel oil | kilogram |
| 6. Donglian fuel oil | 15. Viscosity |
| 7. Number | 16. Remarks |
| 8. Name | 17. Centistoke |
| 9. Weight ton/cubic meter | 18. Wax content |
| 10. Flash point | 19. Asphalt |

II. Transporting and Heating the Fuel of Coal and Oil Mixtures

The quality of coal used for power generation in our nation is poor. The ash content is high and the thermal value is low. When using it to prepare fuel of coal and oil mixtures, if the weight ratio of powdered coal is too low, the result of conserving oil would not be great. If the proportion of coal is too large in the mixture, loss due to drag and wear of equipment are sizable. In theory, when the concentration of powdered coal in mixed fuel reaches a definite proportion, the coal granules will become close to each other and fluid characteristics will not be manifested anymore.

1. The data on viscosity of fuels of coal and oil mixtures with different concentrations of powdered coal show that the higher the concentration of powdered coal, the larger the viscosity. When the weight ratio of powdered coal reaches 50 percent, the viscosity drastically rises (See Figure 3). Therefore, the mixed fuel generally used has a limit of 50 percent concentration of powdered coal.

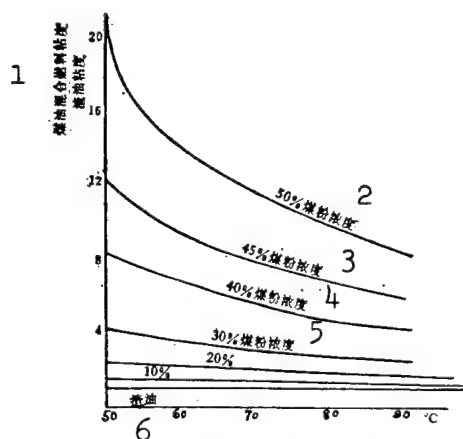


Figure 3. Viscosity ratio of coal and oil mixture and residual oil

Key:

1. Viscosity of coal and oil mixture
2. Viscosity of residual oil
3. 50% concentration of powdered coal
4. 45% concentration of powdered coal
5. 40% concentration of powdered coal
6. 30% concentration of powdered coal
6. Residual oil

Referring to the measurements and analysis of viscosity of the dense suspension liquid of the solid and liquid phases, the viscosity of coal and oil mixture can be calculated according to the following formula:

$$\frac{\mu_m}{\mu_o} = 1 + K_1\phi + K_2\phi^2 + K_3\phi^3 \quad (1)$$

where μ_m is the viscosity of the oil and coal mixture;

μ_o is the viscosity of fuel oil;

ϕ is the volume content of powdered coal which can be calculated from the true specific gravity of coal and the weight ratio.

At a temperature of 60°C, the viscosity of the fuel of coal and oil mixture now is use is

$$\frac{\mu_m}{\mu_o} = 1 + 0.07683\phi - 0.0038\phi^2 + 0.00023\phi^3 \quad (2)$$

From this we can derive the viscosity of mixed fuel with different concentrations of powdered coal. But we should note the effects of different types of coal, different types of oil, temperature and the viscosity of powdered coal.

2. When the weight ratio of powdered coal reaches 30 percent, the fuel of coal and oil mixture visibly manifest itself as a Bingham plastic fluid. But the concentration of powdered coal actually used is still higher. The diameter of the transporting pipe is not large, and the flow is laminar flow. Therefore, the drag coefficient can be calculated using the following formula:

$$F = \frac{16}{N_{Re}} \quad (3)$$

where $N_{Re} = \frac{D^n V^{2-n} \rho}{\gamma}$, is called the combined Reynolds number, and where

D -- diameter of the pipe;

V -- average speed of flow;

ρ -- density of fluid;

$\gamma = K \left(\frac{3n+1}{4n} \right)^n 8^{n-1}$; where

K -- the power rule coefficient of a non-Newtonian fluid;

n -- the power rule index of a non-Newtonian fluid.

In this way, we can use a general formula for calculating the drag in laminar flow to find the drag in the flow of a coal and oil mixture. Only the Reynolds number is different. The transport drag of the mixed fuel currently used is about 1.5 to 2 times the drag in residual oil under the same conditions. Because of a lack of accumulated experimental data, the above formula is presented only as a reference for design.

3. Because convection heat exchange in the coal and oil mixture is poor, therefore, if we use an ordinary heater, then under the same conditions, the total heat exchange coefficient would only be 1/3 to 1/2 that of residual oil. Therefore, the heater will have to be large and metallic consumption is large. Foreign nations use a measured intake heater. The coal and oil mixture is stirred and heated during the course of flow. This can increase the heat exchange coefficient 2 to 3 times. Therefore, according to the experience of designing and using the spiral tube box type heater, we designed a spiral tube box type heater that allows the coal and oil mixture to flow inside the tube and to be heated by steam outside the tube. In this way, when the coal and oil mixture flows inside the spiral tube, the direction of flow constantly

changes, and secondary flow inside the tube is created, thus greatly improving the convection heat exchange of the mixed fuel. The total heat exchange coefficient can reach over 60 kilocalories/square meter/hour°C, approaching the heat exchange coefficient of ordinary encased heaters for residual oil. The dimensions have also been reduced greatly and it can be conveniently installed at the outlet of the transporting pump and the drag in transport is reduced.

4. The electrical capacitance on the transport pipe can be used to measure the concentration of powdered coal in the mixed fuel, adjust ventilation during operation, and monitor the speed of flow of silting to prevent the pipes from being blocked or to prevent disruption in the supply of other fuels.

The dynamic characteristics of switching between mixed fuel of different concentrations of powdered coal and residual oil are different (See Figure 4 [not reproducible]). This switching characteristic is very important to starting shutting down boilers or switching fuels in case of emergency.

III. Results of Combustion and Tests of Coal and Oil Mixture

The ignition and burning characteristics of the coal and oil mixture burned in an oil-fired boiler and the effect upon the output and efficiency of the boiler are very important questions. How to guarantee safe and reliable operation of the boiler is also not to be overlooked.

1. The heat differential scale was used to measure the weight loss and heat release under slow heating of powdered coal, residual oil, and the coal and oil mixture. The results are shown in Diagrams 5 and 6. It can be seen from the heat differential curve that residual oil and the coal and oil mixture both absorb heat between 100 and 200°C. There is a heat release and heat absorption fluctuation between 400 and 500°C. The speed reaches the high peak of heat release. Although the high peak of heat release shifts towards the high temperature section as the concentration of powdered coal in the coal and oil mixture increases, the general trend approaches that of residual oil. Therefore, it can be believed that the ignition characteristics of the coal and oil mixture are not too different from those of residual oil.

The similarity between coal and oil mixture and residual oil and the difference between the mixture and powdered coal can be seen more clearly in the weight loss curve. Although the time for complete burning of the mixed fuel increases as the content of powdered coal increases, it is still much shorter than the time needed for complete burning of powdered coal. This shows the combustion space for combustion of the coal and oil mixture is much smaller than ordinary powdered coal boilers. Therefore, when an oil-fired boiler is changed to using coal and oil mixture, the output may not drop by a large scale.

2. In the selection and design of the ventilator and spout for atomization of mixed fuel, we must first consider a design for a burner that can switch between residual oil and coal and oil mixture to guarantee safe and reliable operation. At the same time, we must pay attention to the effect of combustion and filling the combustion space. The current circular flow flame

stabilizer and the planar flow ventilator being used can guarantee stable ignition and can also avoid caking inside the ventilator. Also, the operation is simple and a lot of experience in design and use has already been accumulated domestically.

Using an internal mixing spout with steam assisted atomization allows the steam to heat the mixed fuel further to improve its atomization characteristics and the position of the spout can be adjusted to regulate the shape of the flame. Also, high speed circular flow is not present and there is less wear on the spout.

Cold and hot tests of the atomization spout from 200 kilograms/hour to 900 kilograms/hour enabled us to design a series of small capacity spouts suitable for use on ordinary oil-fired boilers. The section of the duct in front of the mixing chamber for the coal and oil mixture can be calculated according to the following formula:

$$F = \frac{100G}{36\mu\sqrt{2g\gamma\Delta P}} \quad (\text{millimeter}^2) \quad (4)$$

where G - amount of coal and oil mixture, kilogram/hour;

μ - flow coefficient, we can use 0.65;

γ - Weight of the coal and oil mixture, kilogram/meter³;

ΔP - Difference in pressure between the entry pressure P_m of the coal and oil mixture into the spout and the pressure at the mixing point, (i.e., $\Delta P = P_m - \beta P_j$, where P_j is the pressure of the steam, β is the coefficient found in Figure 7), kilograms/centimeter²

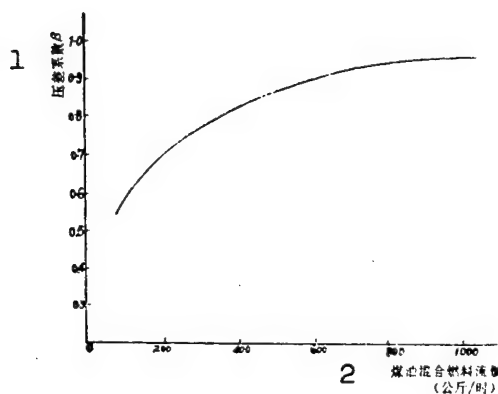


Figure 7. Correction coefficient of pressure difference of mixing and atomizing dissociated substances

Key:

1. Pressure difference coefficient β
2. Amount of flow of the coal and oil mixture (kilogram/hour)

Then, we can select the dimension of the steam ducts using the sectional ratio 0.7 to 1.0 between the steam duct and the duct for the coal and oil mixture. From this, we can determine the loss of steam. The formula for calculating this is as follows:

$$G_j = \frac{36\mu_1 F_1 \psi}{100} \sqrt{\frac{P_j}{V_j}} \quad \text{kilogram/hour} \quad (5)$$

where F_1 - section of the steam duct, millimeter²;

V_j - specific volume of steam, meter³/kilogram;

ψ - Coefficient, 2.09 for over heated steam, 1.99 for saturated steam;

μ_1 - Flow coefficient found in Diagram 8 [not reproducible].

We can believe that after the steam enters the mixing chamber, it expands to a critical pressure. We then use the following formula to calculate the section of the spout of the mixing chamber, and make many small holes according to the requirements of the shape of the flame.

3. A mixed fuel of powdered bituminous coal and Wuqiu residual oil was test burned in a 15 ton/hour oil-fired boiler with a designed heat load capacity of 230×10^3 kilocalories/meter³. This showed that when the concentration of powdered coal in the coal and oil mixture reaches 40 percent, the output of the boiler basically does not change but the efficiency of the boiler drops slightly. The fuel used and the test results of burning are shown in Tables 3, 4 and 5.

When burning a coal and oil mixture with a concentration of powdered coal reaching 50 percent, the filter is frequently blocked. Steam had to be used frequently to clear the filter. This interrupted the fuel supply and thus the output of the boiler dropped by a large scale.

IV. Conclusion

In summary, we believe:

1. The use of coal and oil mixture to replace fuel oil in domestically produced small fuel boilers does not greatly affect output and efficiency.

2. Combining the characteristics of the coal used for power production in our nation and the characteristics of fuel oil, we studied low temperature storage, medium temperature transport and high temperature atomization. If the quality of coal used for generating power can be improved, if the ash content can be reduced, then the results of oil conservation will be improved, and the stability of coal and oil mixture can be improved.

3. The theoretical analysis of the system for preparing coal and oil mixture described, the heater, drag in transport, the schemes and design of the atomization spout, all have general significance. But the concrete numerical values and the type of coal, the type of oil, the granularity of powdered coal are related to concrete conditions.

Table 3 Analysis of the elements in fuel and thermal values

3) 燃料	1) 项目 2) 数值	6) 元素分析 %							14) 低位发热量
	值	碳 C 7)	氢 H ₂ 8)	氧 O ₂ 9)	氮 N ₂ 10)	硫 S 11)	水 W 12)	灰 A 13)	Q _d 大卡/公斤
4) 伍邱渣油		86.34	11.93	0.74	0.51	0.48	—	0.74	9837
5) 混合烟煤		66.11	3.96	7.57	0.97	1.27	1.26	18.86	6311

Key:

- | | |
|--------------------------|--|
| 1. Item | 9. Oxygen |
| 2. Numerical value | 10. Nitrogen |
| 3. Fuel | 11. Sulfur |
| 4. Wuqiu residual oil | 12. Water |
| 5. Mixed bituminous coal | 13. Ash |
| 6. Analysis of elements | 14. Low level heat emission Q _d |
| 7. Carbon | kilocalorie/kilogram |
| 8. Hydrogen | |

Table 4 Composition of Granules of Powdered Coal

1) 筛号	80	100	120	140	160	180	200	3) 过 200 筛	4) 损耗
2) 筛上剩余, %	2	5	2	2	12	13	2	70	2

Key:

1. Sieve number
2. Residues on sieve
3. Passing through sieve 200
4. Loss

Table 5 Contrast between the burning of oil and burning of coal and oil mixture in the 15 ton/hour fuel oil boiler to drive a 2000-kilowatt steam turbine generator

3) 燃料	1) 项目	10) 低位发热量 Q_d 大卡/公斤	11) 发电机出力 千瓦	12) 燃烧室出口过 量空气系数 α_1	13) 排烟过量 空气系数 α_2	14) 灰中可 燃质含量 %	15) 锅炉效率 η %
	2) 数值						
4) 伍 邱 渣 油		9837	2040	1.17	1.74	14.23	79.6
5) 煤 油 混 合 燃 料	6 含煤粉重量比20%	9137	2040	1.26	1.97	22.64	79.6
	7 含煤粉重量比30%	8787	1900	1.32	1.79	34.59	77.0
	8 含煤粉重量比40%	8437	2029	1.22	1.75	—	75.3
	9 含煤粉重量比50%	8087	1341	1.85	2.15	44.70	70.7

Key:

1. Item
2. Numerical value
3. Fuel
4. Wuqiu residual oil
5. Coal and oil mixture
6. Containing weight ratio of 20% of powdered coal
7. Containing weight ratio of 30% of powdered coal
8. Containing weight ratio of 40% of powdered coal
9. Containing weight ratio of 50% of powdered coal
10. Low level heat emission Q_d kilocalorie/kilogram
11. Output of generator Kilowatt
12. Surplus air coefficient at exit of combustion chamber α_1
13. Surplus air coefficient in smoke exhaust α_2
14. Content of combustible substances in unsettled dust
15. Efficiency of boiler η

At present, although some experience concerning the preparation, transport and burning of coal and oil mixture has been accumulated, it needs to be tested in operation over a long period in industrial production. Tests on certain imported boilers with relatively high heat load capacity and typical types of coal and types of oil, and studies of fuels, studies of the distribution of ash and the treatment of ash still have to wait until our powdered coal preparation system is established and until porosity testing has been perfected before they can be gradually conducted.

In addition, according to the current world market prices for heavy oil, coal and coal and oil mixture, and combining the characteristics of our nation's coal and oil resources and labor force, producing a mixed fuel of coal and heavy oil for export is also a path of development that can be considered.

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9296

CSO: 4013/23

NEW TECHNOLOGY

UTILIZATION OF HEAT OF SLAG FROM FLUIDIZED BED BOILER

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese, No 1, 15 Feb 82
pp 33-36

[Article by Sun Nanchun [1327 0589 2504]: "Utilization of the Heat of Overflowing Slag in a Fluidized Bed Boiler"]

[Text] I. Foreword

The fluidized bed boiler manifests a broad adaptability for fuel because of its superior method of burning. At present, this burning method is mostly used to burn poor quality fuel with a heat output of less than 3,500 kilocalories/kilogram. For example, this method is used by power stations built at pit entrances near coal mines to burn waste coal rocks. It is used to burn bone in bone coal producing regions. It is used to develop comprehensive utilization. It is used to burn other poor quality fuel and waste slag of industrial furnaces and kilns by suiting measures to local circumstances. This method of burning has important practical significance in conserving energy, rationally utilizing natural resources, and promoting the buildup of the four modernizations. Poor quality fuel generally has a very high ash content. The amount of slag released by boilers is large. The loss of heat of slag is also very sizable. This must be utilized and it is a problem that cannot be neglected in energy conservation. For example, the low level heat output of the usable base $Q_{DW}^V = 2000 - 1000$ kilocalories/kilogram. The ash content $A^Y = 60 - 78$ percent, and q_6 is as high as 6 to 11 percent. Under this situation, the problem of utilizing the heat of ash and slag becomes an especially outstanding problem.

II. The Method of Utilizing the Heat of Overflowing Slag

Slag released by a boiler is mainly overflow slag. The amount of overflowing slag is generally 45 to 65 percent of the total ash content. There are two general methods of retrieving heat:

1. One method uses air as the medium to transport ash and slag to an ash and slag storage area. The ash and slag are cooled and the air is heated. After the air is purified, it is sent to the boiler for burning. Its function is equivalent to an air preheater utilizing ash and slag as the heating source.

2. The second method uses water to absorb the heat of overflowing slag. At present, the boiler is commonly used to supply water. Its function is equivalent to a coal conserving device using ash and slag as the heat source. There are two common types:

i. A water sleeve is installed on the windlass that carries the released slag. The water not only absorbs the heat of the slag and reduces the loss of heat, at the same time, water protects the windlass so that it will not over-heat, deform and malfunction. This method is suitable for use in small boilers.

ii. A retriever of the heat of slag is installed below the overflow spout. Steel pipes of small diameter are bent into snake-shaped pipes, similar in structure to the steel piped coal conserving device. The slag drops from the upper part. Water in the pipes flows upward in a countercurrent to form a larger temperature pressure (See Diagram 1 for structure). This article will mainly discuss this second type of heat retriever.

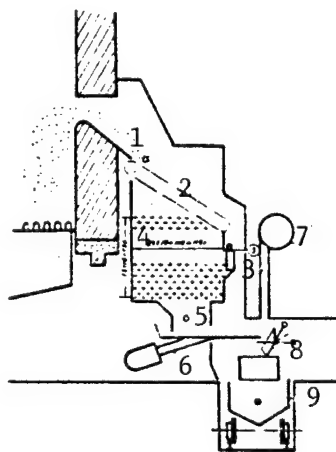


Diagram 1. Illustration of the retriever of the heat of slag

1 -- thermo-electric coupler test point; 2 -- slag filter tube; 3 -- slag level relay; 4 -- slag heat retriever; 5 -- thermo-electric coupler test point; 6 -- slag vibrator; 7 -- duster; 8 -- rotary slag catcher; 9 -- automatic loading dipper

III. Test Results of the Slag Heat Retriever

The slag heat retriever is generally installed below the overflow spout. After the slag overflows from the spout, it drops by gravity. The upper part of the retriever has a slanting slag filter tube to prevent caking of slag into small pellets (with outer diameter of about 20 mm) which may stick between the grid formed by criss-cross tubes and block the passageway. For boilers with a steam output of 10 tons/hour that burn bone coal of $Q_{DW}^Y = 1100$ kilocalories/kilogram, the heated surface of the slag heat retriever is 50 square meters. The supply of water is heated by the coal conserving device and flows into the slag heat retriever. Its function is equivalent to that of the high temperature coal conserving device. Many observations and measurements of long periods have been made during operation. The data were computed and average values were taken. The results are as follows.

The intake slag temperature was 800°C , the exit slag temperature was 511°C , the average temperature drop of the slag was 288°C .

When the average temperature of water flowing into the slag heat retriever was 100.7°C , the exit water temperature was 146.3°C , the average temperature rise of the water was 46°C . This was the average value of the data of 75 effective tests.

The calculated coefficient of heat conduction of the retriever's heated surface was $K_{\text{Average}} = 18.8$ kilocalories/meter²hour. $^{\circ}\text{C}$. This was equivalent to the coefficient of heat conduction of steel piped coal conserving devices of ordinary boilers.

Because the slag heat retriever was installed, the heat loss q_6 of the ash and slag was reduced and the efficiency of the boiler was improved by 3.66 percent. The slag carried away by the slag heat retriever was used to heat water for living, and this part of the heat was not included in the measurements. After exerting efforts, it is hoped that the goal of improving the efficiency by 5 percent can be realized. This would be an outstanding result.

The slag heat retriever releases slag intermittently. The heated surface is submerged in high temperature slag, not just brushing past it. Heat conductivity is good. The submerging time is 5 to 10 minutes depending on the amount of slag.

The sieving characteristics of overflowing slag are as follows:

Compared to fuel, sieving of slag is less at the two ends and more in the middle. In other words, the percentages of large granules and fine powder are both small while the granules of 0.58 to 3.52 mm at the center constitute 60 percent. The average dimension of the granules is 2.55 mm, close to the dimension of the average granules of fuel.

IV. Discussion of Several Different Configurations of Installation

1. Problem of Configuring the Slag Heat Utilizer

The temperature of the slag released by the slag heat utilizer is still about 500°C, and it still has a potential for utilization. But, most of the boilers in use at present have a "Π" configuration. The overflow spouts are all positioned on the back wall. Its height is limited. Therefore, the space for positioning the slag heat retriever is limited, and the heated surface cannot be large. If the slag temperature is lowered to about 300°C, the space would not be enough. In the future, when using the slag heat utilizer, we should include it as part of a whole design of the boiler body. We cannot rely on the final space available for the heated surface.

2. The Effect of the Intake Water Temperature

The temperature of water supplied to low pressure boilers is low, and the temperature of water that is released by the coal conserving device and that is flowing into the slag heat retriever is also not high. The slag temperature at the intake (i.e., the releasing temperature of overflowing slag) varies with the temperature of the upper part of the boiling section, and the range of fluctuation of the temperature is not large. Therefore, the average temperature pressure in the retriever is larger. For example, when the intake water temperature is 100°C, the average temperature pressure Δt can reach 500°C. The temperature of water supplied to medium pressure and high pressure boilers is correspondingly higher. If other conditions remain unchanged, a rise in the intake water temperature means a drop in Δt . The variable values of Δt based on the intake water temperature of 100°C are as follows:

Intake water temperature, °C	100	150	172	215	240
$\Delta t / \Delta t_{100}$	1	0.9	0.86	0.77	0.72

Although the temperature pressure drops and the coefficient of heat conduction drops, they are still higher than those of the steel piped coal conserving device of boilers with the same parameters. Technical and economic comparison shows that they are still feasible.

3. Position in a Steam and Water System

Used as a coal conserving device in the high temperature section of medium and low parameter boilers, its positioning is simple and convenient. When used as a coal conserving device in the low temperature section, its effect is equivalent to raising the temperature of the water supply but it is unfavorable to reducing the temperature of the smoke exhaust. The number of heated surfaces of the air preheater must be adjusted. This system of configuration should not be used for low pressure boilers which do not have a tail air preheater to avoid increasing the loss in smoke exhaust. This can be proven in thermodynamic calculations and in operation.

In industrial boilers not connected to steam turbine generators, softened supplementary water entering the deoxidizer can also be heated. The temperature of such water is lower and a greater temperature pressure and better heat conduction can be maintained. This can reduce the amount of steam consumed by the deoxidizer. Ordinarily, the steam used by such oxidizers come from the saturated steam of the boiler and the waste disposal expander. This system of configuration is one of the more practical and effective plans.

In high pressure boilers, it can still be used as a coal conserving device in the high temperature section. If the slag heat retriever is used as a substitute for the low temperature heater, it is beneficial in heat conduction, but it will increase the number of pipes from the steam turbine room to the boiler. This will reduce the steam drawn by the steam turbine and will also affect the efficiency of the entire power plant. This must be carefully calculated and considered on an overall basis.

Using the slag heat retriever to directly heat water for living and to provide hot water for production use in certain industrial sectors is simple and effective.

V. The Characteristics of Heat Conduction of the Slag Heat Retriever

The slag heat retriever that releases slag intermittently absorbs the small amount of radiated heat from the upper part of the boiling section at the overflow spout. The amount of radiated heat is related to the temperature at the upper part of the boiling section, the area of the spout, the concentration of ash granules in the smoke, and the composition of the smoke. After the slag inside the retriever has been completely released, a small amount of convection heat exchange occurs when hot new slag enters. The main method of heat conduction is contact heat conduction between the solid layer with a definite porosity and the surface of the pipes. Heat conduction is basically composed of two major portions, heat conduction between the solid slag granules and the surface of the pipes and heat conduction between the high temperature gases in the pores and the surface of the pipes. Under the same temperature, the coefficient of heat conduction between solids is generally larger than the coefficient of heat conduction between gases and solids. The porosity is generally smaller, therefore heat conduction between solids is still the main form.

Besides the ordinary factors that affect heat conduction, the additional special factor is obviously porosity. When porosity increases, heat conduction of the gaseous part increases, heat conduction of the solid part drops, and the total coefficient of heat conduction drops. Porosity is determined by the average diameter of the granules, the sieving characteristics, and the characteristics of surface shapes. When the average diameter of the granules is small, the granules are piled up densely and solidly, therefore, the porosity is small and heat conduction is good. But, some experimentally measured data show that when the average diameter is smaller than 2 millimeters, porosity gradually increases. If we use ε to represent porosity, then:

$$\varepsilon = 1 - \frac{\gamma_{\text{pile}}}{\gamma}$$

where: γ_{pile} -- the specific gravity of the slag pile

γ -- true specific gravity of slag

The specific gravity of the pile of bone coal slag is about 0.946, higher than that of bituminous coal and anthracite, and the porosity ε is about 0.4. If the shapes of the slag granules are regular, and if the coarseness of the surfaces is small, then porosity would also be small and heat conduction would be good.

In the entire retriever, the long period of submergence of the slag at the lower part cools the slag longer, therefore the temperature is lower. Upwards, the temperature of the slag gradually rises. Thus, the temperature pressure at the top and the bottom of the layer of granules is different and the coefficient of heat conduction is also different. The numerical value calculated from measured data is actually the average value of the coefficient of heat conduction in the entire layer of granules.

For the single slag granule, the surface temperature of the granule is low while the inner temperature is high. We can imagine the granule as a sphere with the center of the sphere as the "heat source". Heat disperses and propagates throughout the multi-dimensional space of the surroundings and a temperature gradient exists in the direction of propagation. The temperature measured by the thermo-electric coupler and measuring devices at the site of experiment basically reflect only the temperature of the surface layer of the slag granule. The amount of heat released calculated from that temperature is generally 5 to 9 percent higher because only the heat of small granules is fully utilized while the heat at the center of large granules has not been completely released. When the slag granules are cooled, an ash and slag layer of a lower temperature is formed on the surface of the slag granules. This is equivalent to adding a heat resistor on the heated surface towards which the internal heat of the slag granules continues to propagate. Because thermal conductivity of the ash slag is not good, the heat conduction here is different from heat conduction between two types of metals. In addition, the specific heat capacity of ash slag of poor quality fuel is generally larger than the figures given in ordinary boiler technology texts. In general, the situation is complex, and related research is still scarce. Therefore, at present, it is still very difficult to establish precise equations of thermal balance in thermodynamic calculations.

VI. Conclusion

1. When the amount of heat output of a boiler burning poor quality fuel is $Q_{\text{DW}}^Y = 2,000$ to 1,000 kilocalories/kilogram, we must consider the problem of retrieving the heat from overflowing slag. In actual cases of measurement, boiler efficiency can be improved by 3.66 percent. The result of conservation of energy is visible and there is still potential.

2. In the various applications plans, the writer believes that the slag heat retriever is best used as a substitute for the coal conserving device in the high temperature section. It is also rational and feasible to use it to heat chemically softened water. It can also be used to heat water for living and for appropriate industrial production.

3. The method of heat conduction of the slag heat retriever is mainly contact heat conduction between solids. Heat conduction is very complex, and precise calculations of heat conduction still require study. The coefficient of heat conduction is much greater than that of ordinary steel piped coal conserving devices.

9296

CSO: 4013/28

NEW TECHNOLOGY

STONE COAL FLUIDIZED BED BOILER FOR POWER GENERATION PASSES TRIALS

Beijing GUANGMING RIBAO in Chinese 12 Apr 82 p 1

[Article by Zhang Zuhuang [1728 4371 3874]: "Stone Coal Fluidized Bed Boiler for Power Generation Passes Technical Appraisal; Opening New Way of Utilizing Low Calorie Poor Quality Fuel"]

[Text] A new model boiler using stone coal as fuel - 35 ton-per-hour fluidized bed boiler - showed good results after several years of trial use at the Yiyang Bone Coal Power Generation Comprehensive Utilization Experimental Plant [Shimei Fadian Zunhe Liyong Shiyenchang] in Hunan Province. Recently, as entrusted by the First Machinery Ministry, the Hunan Province Science Commission organized all concerned specialists in the country to conduct a technical appraisal on this boiler.

This fluidized bed boiler trial used by the Yiyang plant was jointly designed by the Shanghai Complete Set Power Generation Equipment Design Research Institute of the First Ministry of Machine Building and the Shanghai Boiler Plant and was manufactured by the Shanghai Boiler Plant. The installation of this boiler was completed in March 1978 and it went into regular service in 1980. By now it has accumulated over 6,000 hours of operating time. At one time, it operated continuously for 1,126 hours. Using stone coal of 900 to 1,000 kilocalories per kilogram, the firing was stable and the various parameters were able to satisfy the requirements of the 6,000-kilowatt turbogenerator. Computed on the basis of 5,000 operating hours a year, 29,000 tons of bituminous coal can be saved each year. Involved specialists believe that this type of boiler has opened a new road for solving the burning problem of low calorie poor quality fuel and for the comprehensive utilization of our nation's energy resources.

The use of stone coal in a 6,000-kilowatt power generation boiler is not known to have had a precedent either here or abroad. During the experimental process, the Hunan Province Electrical Design Institute undertook the design of power station accessory equipment. The Shanghai Complete Set Power Generation Design Research Institute, Hunan Province Electrical Design Institute, Huazhong [Central China] Institute of Engineering, and Zhejiang University separately conducted considerable experimental work in their related areas, developed some definite scientific data, and wrote a number of research papers. These will provide the scientific basis for the future design of large fluidized bed boilers.

The specialists who attended the appraisal meeting pointed out that in order to fully develop our country's energy resources it is necessary to develop new innovations on the foundation of this achievement. Further improvements should be made of the boiler wall piping and the boiler structure in order to extend their operating life, improve heating efficiency, and properly solve the desulphurization problem.

5974

CSO: 4013/66

POWER NETWORK

CHINESE SELECT FOREIGN-MADE 500KV CIRCUIT BREAKERS FOR PING-WU LINE

Beijing DIANLI JISHU [ELECTRIC POWER] No 3, 5 Mar 82 pp 29-30

[Article compiled by Yang Qiuqi [2799 4428 3217] of the Foreign Affairs Office of the Ministry of Electric Power: "Selection of 500KV Circuit Breakers for Ping-Wu Transmission Line"]

[Text] China's first Pingdingshan-to-Wuhan 500KV ultra-high voltage transmission line currently under construction uses some imported electric equipment including 500KV equipment at the three substations at Pingdingshan, Shuanghe and Wuchang. When this foreign equipment was imported, the associated manufacture technologies were imported simultaneously. We now introduce the selection of the 500KV circuit breakers and their technical characteristics.

I. The Selection Process

We investigated the SF₆ (sulphur hexafluoride) open circuit breaker manufactured by the French company Merlin-Gerin, the SF₆ canister circuit breaker made by HIT in Japan, the pneumatic circuit breaker made by the French Alsthon company and the Swiss BBC, and the low oil circuit breaker with close switch resistor of the Swiss company ASEA. According to the usage situation in Western Europe, North America and Asia, oil-free circuit breakers are seldom used in 500KV transmission lines and there is a lack of operating data. In 500KV networks built before the 1960's, pneumatic circuit breakers were used. However, since SF₆ circuit breakers with a single voltage arc elimination chamber using SF₆ gas as the arc eliminating medium were put into use in ultra-high voltage networks, they have displayed superior characteristics. The SF₆ circuit breakers have the following advantages over the pneumatic circuit breakers:

1. Pure SF₆ gas is stable and nontoxic and has a high insulation ability. SF₆ gas at a pressure of 3 kg/cm² has the same insulation ability as transformer oil. It has a good thermal conductivity, forms relatively narrow arc column and the time constant of the arc is far smaller than that of arc. It also has the property of absorbing electrons and recombining with positive ions which reduces the number of free electrons in the spark gap and thereby decreases the electrical conductivity of the spark gap. After the arc dies out, the medium can sustain a high rate of voltage recovery and the circuit breaker can reliably turn off different malfunctions without the need to install parallel resistors.

2. The SF₆ circuit breakers are simple in structure and easy to maintain and operate. Because they have the characteristics described above, they can easily be made into large on-off capacity circuit breakers. For example, to turn on or turn off a 500KV, 50KA short-circuit current with SF₆ gas at a pressure of 5 to 6 bars (1 bar = 1.02 kg/cm²), only 4 breaker points are needed whereas 6 breaker points are needed to turn on or turn off a 500KV, 40KA current with gas at 20-25 bars. The amount of machine work needed for SF₆ circuit breakers is only 40 to 50 percent of that required by pneumatic circuit breakers. SF₆ gas recovers after dissociation by the electric spark and the insulation power of the gas does not drop after turn on or turn off. The contact head suffers only minor burning damage in SF₆ gas and can be used for many repeated on-off operations.

But the following problems should be considered in using SF₆ circuit breakers:

(1) SF₆ is a gas that can easily be liquefied and the condensation point is pressure dependent. For the SF₆ circuit breakers selected for the Ping-Wu project, the condensation point is -31°C for a pressure of a 5 bars and a current of 50KA, and the condensation point is -40°C for a pressure of 3 bars and a current of 40KA. According to temperature conditions in China, this type of circuit breaker can be used over a large region.

(2) If the transmission network requires staged close-switch resistance and one-cycle total on-off time, it is so far difficult to achieve with SF₆ circuit breakers. The networks in China will not have this technical requirement in the near future.

According to price quotes by foreign manufacturers and our survey, the price of 50KA SF₆ circuit breaker (open style) is only about 10 percent higher than those of 40KA pneumatic circuit breaker (pneumatic pressure system extra) and the low oil circuit breaker but the performance of the SF₆ breaker is superior. Considering the principle of importing advanced products that suit the domestic need and are reasonably priced, we have decided to import the SF₆ circuit breakers.

II. Model selection

The foreign-made 500KV SF₆ circuit breakers in operation today have three structural models: open style porcelain column model (the European model), ground level canister shock-resistance model (the Japanese model) and the totally enclosed model. Because the Ping-Wu engineering project does not have special requirements regarding earthquake and field layout, it is most economical to employ the open style porcelain column model. The open model circuit breaker has two different types of arc elimination chambers, the circuit breakers made by the Merlin-Gerin company in France are of the single-voltage, dual-nozzle, variable-separation type and circuit breakers made by the Siemens company in West Germany are of the single-voltage, fixed separation type. In comparison, the former has the following advantages: the structure of the arc elimination chamber is simple, the inertia of the SF₆ gas compressing device is small and the arc elimination time is short, the space between the contact head and the porcelain steeve can be

fully used to increase the arc length and help arc elimination, the dimension of the top portion of the porcelain jacket can be made small to reduce manufacture cost, the distance between the break points is large and can withstand high voltage and it can easily handle large on-off capacity and two-cycle total on-off time. Besides, it is difficult to achieve 3 bars, -40°C and 40KA with the fixed-separation model and its patent fee is very high. Hence, the decision has been made to import the device and patent of the French Merlin-Gerin variable-separation type arc elimination chamber structure.

The major specifications of the SF_6 single-voltage open style porcelain column circuit breakers to be used on the Ping-Wu transmission line are: voltage is rated at 550KV, current is rated at 3150 A, 4 contact points, SF_6 pressure is rated at 6 bars, on-off short-circuit current is rated at 50KA, total on-off time is 45 msec, closed-switch resistance is 400 ohm, maximum operating over-voltage factor is 2 and ground shock test voltage is 1800 KV (peak value).

III. Technical characteristics

The principal technical characteristics of the SF_6 circuit breakers selected for the Ping-Wu transmission and transforming engineering project are as follows.

1. Continuous on-off current characteristics

The Merlin-Gerin company has tested the same model SF_6 circuit breakers rated at 40 KA with continuous on-off tests for short-circuit, near-field malfunction and reverse-phase breaking. A total of 4066 KA has been tested in 737 times of turn-off and 105 times of turn-on-off-on-off. The entire testing procedure required no service, no gas replenishment, no gas fittering and the circuit breakers passed the insulation tests conducted according to the International Electrical Engineering Commission standards afterwards. The number of guaranteed continuous breaking current and number of operations are listed below:

Breaking Current (KA)	63	50	40	25	3.15
Number of Operations	10	14	20	90	5000

2. Mechanical operation tests

Five circuit breakers were tested for 10,000 on-off operations under the following conditions: First 1000 operations were made at normal temperature and then the temperature was rapidly dropped to -25°C and another 1000 operations were made, the temperature was then raised to $+40^{\circ}\text{C}$ and an additional 1000 tests were made, 2000 operations were then made under normal temperature in a humid environment, followed by 100 percent breaking tests and finally they were tested 5000 times under normal temperature.

3. Selection of close-switch resistance

The Merlin-Gerin company has conducted breaking tests of 500 KV, 800 A capacitive current and 500 KV, 245~1000 A inductive current with an over-voltage factor less than 1.4. No-load turning-on tests were made for 500KV, 400 km

transmission line on an Italian transient network testing equipment. When 360 ohm close-switch resistance was used, the over-voltage reached 2.2 times without parallel compensation and 1.5 times with 40 percent compensation provided by parallel reactance. Based on transient network analysis made specifically for the Ping-Wu transmission line, it was decided to use a single-stage 400 ohm close-switch resistance, the engagement time is 8 ± 1.5 msec and the over-voltage factor is no more than 2.

4. Gas leakage rate

In 95 percent of the cases, the SF₆ gas leakage rate is no greater than 0.05 bar/year, the worst case is less than 0.3 bar/year and the gas should be replenished every 3 years or so.

5. Installation and adjustment

The complete set SF₆ circuit breakers are adjusted and tested by the manufacturer and each column is separated into three parts: the top arc elimination chamber and the parallel resistor, capacitor and container, mid-section supporting porcelain bottle, push rod, and hydraulic cylinder, and the bottom support legs. They are assembled on site. In Wuchang substation, it took approximately 1 week to assemble one set of circuit breakers including charging with gas and the mechanical operation tests. The action time of the assembled unit is in agreement with the manufacturer's test data. For example, the characteristic open-switch time is 20 msec (26 msec specified in the contract) and the maximum asynchronous time interval between the in-phase and out-of-phase break points upon open switch is 1.5~2 msec (2 msec specified in the contract). The 13 sets of 500 KV SF₆ circuit breakers used in the Ping-Wu transmission line were all installed and adjusted by early August 1981. They will provide valuable experience of using this new technology in ultra-high voltage power grids in China.

9698

CSO: 4013/46

POWER NETWORK

POWER OUTPUT ESTABLISHES ALL-TIME RECORD IN GUANGDONG

Guangzhou NANFANG RIBAO in Chinese 6 Apr 82 p 2

[Article: "Power Output in Province Establishes All-Time Record in First Quarter; Total Output of Over 3.1 Billion Kilowatt-hours Exceeds Plan by More Than 400 Million Kilowatt-hours"]

[Text] An unprecedented situation has developed in our province's electrical power production in the first quarter of this year. The best seasonal records were established for the economic technical indicators of generating capacity, coal and water consumption, and the rate of plant consumption. Statistics show that the province's power output was over 3.11 billion kilowatt-hours, exceeding the plan by over 410 million kilowatt-hours and representing an increase of 22.6 over the same period a year ago. Of the total, output of provincial power plants was more than 2.36 billion kilowatt-hours, an increase of 21 percent over the same period a year ago. Water consumption of hydroelectric plants, coal consumption of thermoelectric plants, and the rate of electricity use by the power plants themselves all showed large-scale reductions.

Although water supply for our province's hydroelectric plants has increased slightly this year, inadequate fuel supply difficulties have widely plagued the thermoelectric plants. Except for the Huangpu Power Plant, fuel supplies for the other power plants have decreased by nearly a quarter as compared to the same period last year. In order to alleviate the tight electric power supply situation under these conditions, the various power plants conscientiously strengthened their enterprise management in an effort to produce even more power through smaller consumption. In the first quarter of this year, the total water supply for the seven major hydroelectric plants of the Guangdong electric network increased by only 15 percent over the same period a year ago. However, because of the strengthening of the rational economic management of the reservoirs to keep the generators operating at specific high water levels, the generating capacity actually increased by 62 percent. Compared to the first quarter of a year ago, the average daily output of the hydroelectric plants increased by 1,790,000 kilowatt-hours, the average water consumption for each kilowatt-hour of electricity was reduced by 0.5 cubic meters, and over 50 million kilowatt-hours of electricity were generated from the water conserved.

Aimed at the difficulties of inadequate fuel supply for the thermoelectric plants, electric power departments in the province rationally arranged the

operations of the generators within the system. High temperature, high pressure generating units of low energy consumption and high efficiency were run more often and the operating time of medium temperature and medium pressure and low temperature and low pressure units was reduced. As a result, good economic benefits were achieved. Statistics show that the percentage of electricity generated by high temperature, high pressure generating units in the Guangdong electric network increased from 85.7 percent in the first quarter of last year to 90.3 percent in the first quarter of this year and their output increased by more than 230 million kilowatt-hours. The consumption of standard coal for each kilowatt-hour of electricity generated was reduced by 6 grams. Total savings of standard coal amounted to over 10,000 tons.

5974

CSO: 4013/66

POWER NETWORK

LIANCHENG POWER PLANT JOINS LANZHOU POWER GRID

Lanzhou GANSU RIBAO in Chinese 2 Feb 82 p 2

[Text] The Liancheng Power Plant is another large thermoelectric generating plant newly constructed in our province. It is the important center in the northwest section of the Lanzhou power grid. Recently brought into the grid, its No. 1 generating unit in the first stage construction has a capacity of 100,000 kilowatts. This will have a positive effect towards gradually establishing a balance between hydroelectric power and thermoelectric power in our province and it will provide a new energy source for industrial and agricultural production.

The time between ground breaking and the time that No. 1 generating unit joined the power grid for power generation was 3 years and 5 months. Builders from different places worked diligently to put up the large plant building and installed more than 1,000 pieces of equipment of various kinds. All the installations have machinery produced domestically, including a large 100,000-kilowatt turbogenerator with inner water-cooled stator and rotor, a new completely suspended semi-open-air steam drum boiler, and a lower power consumption and high safety factor booster station.

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CSO: 4013/17

POWER NETWORK

BRIEFS

GUANGXI POWER TRANSMISSION LINES--Since last year, the Nanning municipal power grid has added 34 new 10 kilovolt to 110 kilovolt high-tension power transmission lines. Of these lines, 22 lines are used in agricultural production and the majority of them have been erected in the western suburbs of Nanning Municipality where in the past, there were few transmission lines and capacity for transmitting power was low. [Nanning Guangxi Regional Service in Mandarin 1100 GMT 20 May 82 HK]

GUANGDONG IMPROVES POWER GRID--To meet the needs in industrial and agricultural production and to make full use of resources of small hydroelectric power stations, electric industrial departments in Guangdong Province have vigorously improved the power grid. Over the past few years, they have erected a large number of 110,000-volt key transmission lines and subsidiary projects. To supply electric power evenly, over the past few years, electric power departments in the province have formulated plans, raised funds, erected 110,000-volt key lines, increased voltage and increased the capacity of transformers. The electric lines from Guangning to Huaiji and from (Longxidai) to (Qixinggang) in Qingyuan. A total length of some 180 kilometers have been completed and put into operation. The lines from (Zhaigang) to (Huangniutan) and Xinfeng and from Longmen to Zengcheng are under construction. [Guangzhou Guangdong Provincial Service in Mandarin 1000 GMT 10 Apr 82 HK]

HUNAN, JIANGXI POWER GRIDS--The power grids of Hunan and Jiangxi provinces will soon be amalgamated with the Central China power grid to ensure unified management and a united power grid throughout Henan, Hubei, Hunan and Jiangxi provinces. The total installed capacity of the Central China power grid will be the greatest of the six large power grids throughout the country. The Central China power grid can make full use of a large number of large and medium-size hydroelectric power stations, such as Gezhouba powerplant, to supply a large amount of cheap electricity to people in Central China and can also regulate the supply of hydroelectric power and thermoelectricity. At present, the power grids of Hubei and Henan provinces have been amalgamated and the amalgamation of the power grids of Hubei and Jiangxi provinces is being stepped up. The amalgamation of the power grids of Hubei and Hunan provinces is now included in the state plan and preparations for the amalgamation work are being made. [Wuhan Hubei Provincial Service in Mandarin 1100 GMT 30 May 82 HK]

CSO: 4013/86

SHANXI POWER GRID--To correct the problems of power outages and power restrictions, so that consumers cannot use electricity in a normal manner, which had resulted from inadequate transmission and conversion capacities for many years, the work force on our province's capital power construction front has made new accomplishments. In concentrating on the construction of the large power stations for the two Datong power plants, the Shentou Power Plant, and the Niangziguan Power Plant, a large 200,000-kilowatt unit joined the power grid last year. At the same time, eight substations were either newly constructed or expanded. Total capacity of the transformers placed in operation was 451,500 kilovolt-amperes, including four large transformers with a total capacity of 360,000 kilovolt-amperes. Transmission lines placed in operation totalled 330 kilometers, including 210 kilometers of 220,000 volts. [Taiyuan SHANXI RIBAO in Chinese 2 Feb 82 p 1] 5974

PROVINCIAL ELECTRICITY BUREAU GAINS VICTORY--The large staff and workers of the Provincial Department of Electricity overcame difficulties, used every possible means to strive for greater power generation and supply, and completed the planned quantity of electricity to be generated seven days ahead of time. A total of 1,223 million kilowatt-hours of electricity were generated in the first quarter, an increase of 8.2 percent over the same period of last year. Both output and profits increased over the same period a year ago. The consumption of thermal power plant coal also decreased as compared to the same period last year. [Kunming YUNNAN RIBAO in Chinese 3 Apr 82 p 1] 5974

CSO: 4013/17, 56

RURAL POWER CONSUMPTION INCREASES--Along with the increase of power generation in the countryside following the implementation of the policy of national economic readjustment, power consumption in rural areas throughout the country reached 42 billion KWH in 1981, an increase of 14 percent over 1980. Since the 3rd Plenary Session of the 11th Party Central Committee and the introduction of the system of responsibility for production in the countryside, commune- and production brigade-run enterprises have developed rapidly and the consumption in 1979 was 23 percent more than in 1978; in 1980 it was 30 percent more than in 1979; and in 1981 again it was 38 percent more than in 1980. The consumption of electricity by the commune- and production brigade-run enterprises amounted to one-fifth of the total consumption in the countryside. The increase in peasants' income has brought a constant flow of TV sets, electric fans and other household appliances to the rural areas and a fairly large increase in power consumption for illumination and other daily needs in these areas. [Text] [Beijing GUANGMING RIBAO in Chinese 2 Jan 82 p 1] 9411

CSO: 4006/262

HYDROPOWER

SHANGHAI PAPER URGES START ON CHANGJIANG PROJECT

HK080242 Beijing CHINA DAILY in English 8 May 82 p 4

[Text] The time is ripe for China to start work on a huge new hydroelectricity project which would tame the Changjiang River and provide power for cities as far north as Beijing and as far south as Hong Kong, according to Shanghai-based WORLD ECONOMIC HERALD [SHIJIE JINGJI DAOBAO].

The paper says the project, known as the Sanxia key water control project will relieve the threat of flooding in the middle and lower reaches of the Changjiang River Valley. It will also supply electricity to the cities of Beijing, Tianjin, Tangshan, Shanghai, Ningbo, Hangzhou and Guangdong, Sichuan provinces, as well as Hong Kong and Macao.

The first phase of the Gezhouba water control project was completed last year and helps control flooding as well as generating electricity.

The second phase of the Gezhouba project is expected to send out electricity in 1986 from 21 generating units.

Yet the Gezhouba project, one of the biggest key water control projects in the world, is only the conveyance system of the Sanxia project. The WORLD ECONOMIC HERALD says the establishment of the Sanxia project will end China's electricity shortage.

The builders of the Gezhouba project believe that 1983 is the ideal time for starting the preparations of the project, which will ensure the beginning of the Sanxia project right after the completion of the Gezhouba project.

The WORLD ECONOMIC HERALD says it has taken 30 years to solve the technological problems of planning, designing and surveying for the Sanxia project.

A programme has been proposed to gain the major part of the investment from the income of electricity generated by the completed parts of the project (such as the Gezhouba project).

CSO: 4010/6

HYDROPOWER

CONSTRUCTION PROGRESSES ON BAISHAN HYDROELECTRIC POWER STATION

Harbin HEILONGJIANG HUABAO [HEILONGJIANG PICTORIAL] in Chinese No 1, 1982, p 6

[Photograph and caption]



A view of the Baishan hydroelectric power station in Heilongjiang

HYDROPOWER

BRIEFS

GUANGDONG TO HARNESS PEARL RIVER--The plan for exploiting and harnessing the Pearl River basin which was put forth by the Ministry of Water Conservation was recently formally approved by the State Capital Construction Commission. From 6-10 April, the Pearl River Water Conservation Committee of the Ministry of Hydroelectric Power held a meeting of relevant departments of six provinces and regions near the basin and established a Pearl River basin planning coordinating group. According to the plan, by the year 2000, when the first phase of the project will be complete, flood control, shipping and irrigation throughout the basin will be remarkably improved and the capacity for generation of electricity will be greatly increased. Exploiting the hydroelectric power resources of the Hongshuihe River in Guangxi will be a key facility in solving the problem of electricity in Guangxi and Guangdong. Harnessing the Xijing River and the Beijing River can guarantee safety in flood control in Guangzhou Municipality and can greatly alleviate the disaster of floods over approximately 10 million mu of fields in the Pearl River delta. [Guangzhou Guangdong Provincial Service in Mandarin 2350 GMT 19 Apr 82 HK]

HAINAN HYDROELECTRIC POWER STATION--The installation of No. 4 generator unit of (Liululing) hydroelectric power station in Hainan region has been completed. The generator unit was tested on 24 April and the tests proved successful. The four generator units of this station have now all been in operation. This station is one of the key hydroelectric power projects throughout the country and the biggest hydroelectric power station in this region. The total installed capacity of this station is 80,000 kilowatts, or 55 percent of the installed capacity of the region's existing large power grid. With the completion of this station, the situation of the short supply of power in this region will be greatly alleviated and the exploitation and construction in the region will be speeded up. [Haikou Hainan Island Service in Mandarin 0330 GMT 28 Apr 82 HK]

GUANGXI HYDROELECTRIC POWER INDUSTRY--Guangxi region abounds in hydroelectric power resources and ranks sixth in the country in this regard. The region has some 900 rivers, each of which has a basin area of more than 50 square kilometers. Some 16 million kilowatts of hydroelectric power resources can be exploited and utilized. In the region, the cost of each 1,000 kilowatt-hours of electricity produced by a hydroelectric power plant is 9 yuan but the cost of each 1,000 kilowatt-hours produced by a thermal plant is 37 yuan. The profit submitted to the state from each 1,000 kilowatt-hours of electricity generated by a thermal plant is 10 yuan. The great majority of hydroelectric

power stations have played an important role in flood control, irrigation, shipping and the breeding of aquatic products and have achieved great economic results. The installed capacity of hydroelectric power stations throughout the region by the end of last year reached 1.218 million kilowatts, 64.9 percent of the total installed capacity of total power stations in the whole region. At present, the region has 226 hydroelectric power stations which each of have installed capacities of more than 500 kilowatts. In addition, the region has some 12,000 small hydroelectric power stations, with an installed capacity of some 600,000 kilowatts, which accounts for 32 percent of the region's total installed capacity. By 1985, the region will require further hydroelectric power stations with an additional installed capacity of 520,000 kilowatts and an additional electricity output of 2.1 billion kilowatt-hours. By 1990, the region will require an additional installed capacity of some 1 million kilowatts of hydroelectric power and an additional electricity output of several billion kilowatt-hours. [Nanning Guangxi Regional Service in Mandarin 1100 GMT 27 Apr 82 HK]

CSO: 4013/87

SMALL-SCALE HYDROPOWER PROJECTS--Last year, Yunnan Province constructed 142 new small-scale hydroelectric stations which will generate 1.213 billion KWH per year, a 31.85 percent increase over 1980. Eighty counties throughout the province depend on these small-scale hydropower stations for a large part of their power supply. Yuanyang, Honghe, and 20-odd other minority counties in the border region already have a number of electric stoves, thus conserving firewood and perserving the forests. [Text] [Kunming YUNNAN RIBAO in Chinese 15 Apr 82 p 1]

CSO: 4013/91

COAL

MAIN PROPERTIES AND UTILIZATION OF CHINESE COALS

Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese, No 3, Mar 82 pp 2-9

[Article by Yang Jinhe [2799 6855 0735] and Chen Wenmin [7115 2429 2404]: "Basic Characteristics and Main Uses of China's Coal"]

[Text] China's coal resources are rich. According to the most recent statistics in terms of standard fuel capable of producing 7,000 kilocalories/-kilogram, the known sources of coal are equivalent to 40 times the known sources of petroleum. Whether at present or in the long-range future, coal will be our nation's main source of energy. Of the total consumption of energy in our nation from 1976 to 1980, coal constituted slightly more than 70 percent, petroleum constituted 22 percent, and natural gas and hydroelectricity constituted 3 percent and 4 percent respectively. In the use of coal, industrial coal constituted about 82 percent (slightly less than 20 percent for power generation, 10 percent as coal concentrate for coking, slightly less than 5 percent for locomotives, and 47 percent for other industrial uses), and civilian coal constituted 18 percent. To rationally utilize coal resources and to improve the rate of utilization of coal and the rate of utilization of thermal energy, the basic characteristics of the various types of coal have been systematically studied and understood. This understanding has important practical meaning for each department that uses coal to learn how to suit measures to local circumstances and conserve energy.

I. Basic Characteristics of the Various Types of Coal in Our Nation

According to the current classification, there are ten main types of coal: lignite, bituminous flame coal, non-caking coal, weakly caking coal, gas coal, fat coal, coking coal, blackjack, lean coal, and anthracite. Each major type of coal has its specific characteristics and suitable uses as described in the following:

1. Lignite

Our nation's lignite reserves are rich. This type of coal is characterized by a large moisture content. W_f is generally 10 to 25 percent. W_Q is 15 to 40 percent. The ash content (A^g) of lignite of some of the mines in Nei Monggol, Jilin and Yunnan is low, mostly below 15 percent. The ash content

of the coal seams of most lignite mines is about 20 to 30 percent. The volatile fraction (V^r) is generally > 37 to 60 percent. The sulfur content (S_Q^g) varies from below 0.5 percent to over 5 and 6 percent. The sulfur content of lignite of the Northeast is lower, generally below 1 percent. The sulfur content of the lignite of Guangdong, Guangxi and Hainan Island is generally above 1.5 to 2.5 percent.

The thermal value of lignite is low. The usable base low level heat output (Q_{DW}^y) of lignite in the few mines in Jilin, Henan and Shandong is relatively high, all above 4,000 to 5,000 kilocalories/kilogram. That of the rest is mostly only 3,000 to 4,000 kilocalories/kilogram. The melting point of coal ash of the early Tertiary lignite in Liaoning, Jilin and Guangdong is relatively high, T_2 often reaches above 1,450°C, T_2 of the rest of the lignite is mostly between 1,250 and 1,400°C. But the melting point (T_2) of lignite of the main mines at Zhalainuo'er, Yima, and Pingzhuang is mostly lower than 1,250°C (Table 1). The melting point of lignite ash drops as the content of CaO in the ash increases. But when the content of CaO in the ash surpasses 30 percent, the melting point of the ash rises as the content of CaO increases.

The content of humic acid (H_{mz}^g) in lignite varies from < 5 percent to > 30 percent. The yield of low temperature tar (T^r) varies between 5 and 20 percent. Light permeability (P_M) generally does not surpass 60 percent. The wax content of lignite (E_B^g) is mostly below 1 percent, but the wax content in some late Tertiary lignite at some mines in Yunnan is as high as 5 to 6 percent. The content of total acidic chemical groups is generally 4 to 6 milligrams equivalent/gram, mainly the phenolic hydroxyl group.

Table 1. Coal quality indices of major lignite mines

Mine	W_Q (%)	A^G (%)	V^r (%)	S_Q^G (%)	Q_{DW}^Y (cal./gram)	T_2 (°C)	H_{mz}^G (%)	Light Permea- bility(%)	Ignition point(°C)
Zhalainuo'er	30~36	5~17	41~46	0.3~0.8	2500~3600	1130 ~ 1400	8~23	33~42	295~298
Pingzhuang	19~29	10~22	40~45	0.5~2.4	3000~3900	1240	5~10	30~42	268~275
Shulan	20~25	23~42	50~56	0.2~0.5	2700~3400	1410~>1500	12~28	30~40	302~314
Yima	5~15	10~25	40~43	0.8~3.1	3500~5200	1190 ~ 1240	2~6	50~57	294~316

2. Bituminous coal not used for coking

Flame coal, non-caking coal, weakly caking coal (most) and lean coal are bituminous coals not used for coking. Their common characteristic is that they do not have a caking characteristic or they are only very weakly caking. But their degree of coalification and their microscopic constituency of the coal stones are visibly different.

Flame coal. Flame coal is a bituminous coal that has the lowest degree of coalification. At present, the Northeast produces the most, including the Fuxin, Fushun Xilutian and Tiefa mines.

The volatile fraction of this type of coal is slightly lower than that of lignite, generally between 37 and 47 percent. The low level heat output is mostly 3,500 to 6,000 kilocalories/kilogram (Table 2). The ash melting point of this type of coal is generally high, T_2 is mostly $> 1300^{\circ}\text{C}$, and the average of T_3 reaches above $1,380^{\circ}\text{C}$. Its yield of tar is mostly higher than 8 to 15 percent. Its resistance to slacking is higher than that of lignite. The y value is 0 to 5 centimeters.

Table 2. Major coal quality indices of flame coal mines

Mine	$W_Q(\%)$	$A^g(\%)$	$V^r(\%)$	$S_Q^g(\%)$	Q_{DW}^y (cal./gram)	Ash melting point($^{\circ}\text{C}$)		Average $H^r(\%)$
						T_2	T_3	
Fuxin	8~16	7~20	37~41	0.5~1.3	3500~4800	1200	1285	5.3
Fushun								
Xilutian	5~12	8~20	44~48	0.5~1.0	4800~5900	>1400	>1445	5.7

Non-caking coal. Non-caking coal is a type of bituminous coal with a low degree of coalification and a very special coal stone constituency. The moisture content is high. The ash content is low. The volatile fraction is generally 25 to 35 percent, and the average sulfur content is lower than 0.8 percent (Table 3). The ash content in raw coal (A^g) averages slightly less than 11

percent, and the moisture content (W^f) is generally 3 to 10 percent. The variation in the heat output of pure coal is larger, from 6,850 calories/gram to 8,100 calories/gram. The chemical reactivity of this type of coal is relatively good. The ignition point is low and the coal burns easily. But the coal ash melting point is relatively low, the average T_2 is only $1,200^{\circ}\text{C}$, and T_3 is mostly $< 1,250^{\circ}\text{C}$. The content of Al_2O_3 in the coal ash is low, averaging 13.1 percent while the average contents of CaO and Fe_2O_3 respectively reach 16.45 percent and 23 percent. The Fe_2O_3 comes mainly from siderite (FeCO_3).

The microscopic constituency of the coal stone of non-saking coal is mainly mother of coal and semi-mother of coal, averaging as high as 49.5 percent, while the average content of vitrain is only 25.65 percent. Although the output of this type of coal is not abundant, the reserves are large, mainly distributed in Nei Monggol and the Northwest.

Table 3. Major coal quality indices of non-caking coal

Mine	W_Q (%)	W^f (%)	A^g (%)	V^r (%)	S_Q^g (%)	Q_{DW}^y (cal./gram)	Ash melting pt. (°C)		Vitrain (%)	Mother of coal (%)
							T_2	T_3		
Jinyuan	4~8	2~5	6~16	25~35	0.4~1.0	5700~6400	<1200	<1250	11~48	28~63
Jiaoping	9~12	3~7	8~13	34~37	0.6~1.0	5500~6100	<1250	1300	50.7	32.5

Table 4. Major coal quality indices of weakly caking coal mines

Coal mines	W_Q (%)	W^f (%)	A^g (%)	V^r (%)	S_Q^g (%)	Q_{DW}^y (cal./gram)	Ash melting pt. (°C)		Vitrain (%)	Mother of coal (%)
							T_2	T_3		
Datong*	5~10	2~5	5~10	28~34	0.5~1.5	6200~6800	1290	1325	38.4	45.0
Baotou	2~5	1~2	14~22	24~26	0.3~1.0	5300~5900	1300	1350	61.0	23.0

*The grindability coefficient of Datong coal ($K_{H.G.}$) is 52 to 64, the ignition point is 320 to 350°C, the percentage of CO₂ decomposition by coal (1100°C) is 60 to 70 percent, H^r is 4.5 to 5.3 percent (averaging 4.8 percent).

Weakly caking coal. The Datong Coal Mines, which produces the most amount of coal in our nation, are typical weakly caking coal mines. The main characteristic of this type of coal is that it has a definite caking characteristic. The value y is 0 (lump) to 9 centimeters, the volatile fraction is relatively high and the ash content is relatively low. The average volatile fraction is 31.2 percent, the average ash content is 10.1 percent, and the sulfur content is mostly between 0.5 to 1.5 percent, averaging slightly less than 0.9 percent. The heat output of this type of coal is generally higher than that of non-caking coal, with a high level heat output (Q_{GW}^r) averaging 8,060 calories/gram. The coal stone constituency is also rather special. The average content of vitrain is 42.5 percent. The average values of mother of coal and semi-mother of coal reaches as high as 39.5 percent (See Table 4). The ash of this type of coal contains more Fe_2O_3 and CaO but the content of Al_2O_3 is less. The melting point T_2 in the productive pits is only 1,228°C, and T_3 is 1,251°C. Besides Datong, which is a weakly caking coal producing mine, there are also the Siahuyuan, Fangzi, Zhengyang, and Zhangxin mines and some coal mines at Baotou. Of these, only the coal produced by the Jinhuaogong Mine has a lower mother of coal content and a relatively high vitrain content suitable for coking. The coal produced by the rest of the mines cannot be used by itself for caking.

Lean coal. Lean coal is a bituminous coal with the highest degree of coalification. Its volatile fraction $V^r > 10$ to 20 percent and its value y is 0 (not in lumps). In addition, the characteristic of lean coal is that it is mostly a type of coal with a high ash content or a high sulfur content. For example, the ash content of the lean coal of Zibo is mostly about 20 to 30 percent, and the sulfur content is as high as 1.5 to 4.0 percent. The ash content and sulfur content of lean coal can be greatly reduced and its thermal value visibly increases after washing. The characteristics and quality of our nation's typical lean coal mines are shown in Table 5.

Table 5. Major coal quality indices of typical lean coal mines

Coal mines	$W_Q(\%)$	$A^g(\%)$	$V^r(\%)$	$S_Q^g(\%)$	Q_{DW}^y (cal.gram)	Ash melting pt.(°C)		Microscopic hardness HV (kilo/sq.cm)
						T_2	T_3	
Zibo	3~4	11~30	12~18	1.5~4.0	5500~6100	1300	1380	34~36
Xishan	4~6	8~23	11~18	0.6~2.2	6200~6800	1335~>1500	1350~>1500	28~31

3. Bituminous coal for coking

Gas coal, fat coal, coking coal and blackjack are our nation's four main types of bituminous coal for coking. The common characteristic of these types of coal is a relatively strong or medium caking characteristic. The strength of coke produced by the different grades of bituminous coal for coking is visibly different. The characteristics and quality of the main types of bituminous coal for coking are separately described below.

Gas coal. The reserves of gas coal is the most abundant and its output is the highest among all types of coal. The proportion of gas coal in East China is very large. Gas coal can be further divided into grade 1 and grade 2 fat gas coal with a slightly lower volatile fraction and a relatively strong caking characteristic, and grade 1, grade 2 and grade 3 gas coal with a slightly higher volatile fraction and a slightly poorer caking characteristic. The characteristic of grade 1 and grade 2 fat gas coal is that their volatile fraction (V_r) is between 30 and 37 percent, their y values are > 9 to 25 centimeters. These types of coal are the main coking coal used by our nation's coking plants. They serve a backbone function in coking. Relatively strong coke can be produced using these by themselves. The strength M_{40} of coke produced by grade 2 fat gas coal listed in Table 6 averages as high as 69.1 percent, and M_{10} averages 10.1 percent. In addition, the sulfur content of fat gas coal is generally below 1 percent and even < 0.5 percent. This is a better type of coal for coking. The characteristics of grade 1, grade 2 and grade 3 gas coal are that their volatile fraction can be as high as 37 to 45 percent, their y values vary from 5 to 25 centimeters, and their caking characteristics also vary relatively greatly. For example, coke produced by grade 1 gas coal mostly cannot be used in the rotary drum test. The strength M_{40} of coke produced by grade 2 and grade 3 gas coal can reach an average of 50 percent, and M_{10} is 13 to 14 percent (Table 6). The coke produced by gas coal is thin and long. It has many longitudinal cracks. It is not strong. Its wearability is poor, but its porosity is high and its reactivity is good. At present, it is mostly used in combination with other types of coal for coking. Because the percentage of tar (T_r) of grade 1, grade 2 and grade 3 gas coal reaches 10 to 18 percent, when more gas coal is mixed for coking, more chemical products and coal gas can be obtained. Variations of the coking indices of this type of coal are listed below (Table 7).

Table 6. Experimental results of using major types of coking coal in the 2,000-kilogram coking furnace

Type of coal	M_{40} (%)	M_{10} (%)	Percentage of pulverized coke(%)
Grade 2 gas coal	$\frac{22.2 \sim 70.9}{51.2(9)}$	$\frac{9.8 \sim 27.0}{14.4(9)}$	$\frac{8.4 \sim 10.8}{10.0(4)}$
Grade 3 gas coal	$\frac{25.2 \sim 72.2}{48.5(6)}$	$\frac{7.1 \sim 17.1}{12.9(6)}$	
Grade 1 fat gas coal	$\frac{36.8 \sim 69.6}{57.4(17)}$	$\frac{9.8 \sim 27.2}{15.4(17)}$	
Grade 2 fat gas coal	$\frac{62.6 \sim 76.2}{69.1(19)}$	$\frac{5.8 \sim 12.7}{10.1(19)}$	
Fat coal	$\frac{55.8 \sim 82.6}{71.4(15)}$	$\frac{4.2 \sim 12.6}{8.4(15)}$	
Coking coal	$\frac{64.2 \sim 82.0}{75.5(46)}$	$\frac{6.3 \sim 15.7}{10.1(46)}$	Main coking coal: $M_{40} 76.2, M_{10} 9.5$
Grade 2 blackjack	$\frac{60.0 \sim 80.5}{73.2(11)}$	$\frac{7.4 \sim 20.9}{12.2(11)}$	

Note: Data in the table are $\frac{\text{smallest} - \text{largest}}{\text{average (number of samples)}}$

Table 7. Range of variation of coking indices of major coking coal

1) 煤种	y (毫米) 8)	R.I	$G_{R.I}$	b (%)	C S N	G~K	Lga (度) 10)
2) 肥煤	>25~60	75~90	>85~110	180~680	6~9	$G_s \sim G_{1s}$	4.41~5.81
3) 焦煤	>12~25	60~85	>60~95	0~200	5~9	$G_1 \sim G_s$	1.80~4.57
4) 瘦煤	0~12	>5~60	>5~60	9) 仅收缩~30	$1 \sim 7\frac{1}{2}$	C~G	0.30~1.48
5) 1、2号肥气煤	>8~25	60~89	>40~95	-20~200	4~9	$G \sim G_s$	2.00~5.00
6) 1、2、3号气煤	>5~25	15~85	>10~90	9) 仅收缩~185	$1\frac{1}{2} \sim 7\frac{1}{2}$	E~G_s	0.85~5.00
7) 弱粘煤	0~9	5~50	9~48	9) 仅收缩~3	$1 \sim 4\frac{1}{2}$	B~D	0.30~1.60

Key:

- | | |
|--------------------------------------|---------------------------------------|
| 1. Type of coal | 6. Grade 1, grade 2, grade 3 gas coal |
| 2. Fat coal | 7. Weakly caking coal |
| 3. Coking coal | 8. (centimeter) |
| 4. Blackjack | 9. Contracts only -- |
| 5. Grade 1 and grade 2 fast gas coal | 10. (degree) |

Table 8. Relationship between the volatile fractions of fat coal with the same y value and M_{40} and M_{10}

V^r (%)	y (centimeter)	M_{40} (%)	M_{10} (%)	Grade
25.3	26	82.6	7.0	Grade 1 coking fat coal
25.7	26(+0.5)	78.1	8.0	Grade 1 coking fat coal
27.2	26(-0.5)	75.2	7.2	Grade 1 fat coal
29.4	26	74.8	8.1	Grade 1 fat coal
30.3	26(-0.5)	72.6	10.4	Grade 1 fat coal
34.4	26	55.8	12.6	Grade 1 fat coal
42.1	26	15.4	22.0	Gas fat coal

Fat coal. Its caking characteristic is the strongest. Its value 7 of maximum thickness of the colloidal layer > 25 to 60 centimeters, its caking index (G_{R-I}) > 85 to 110 (See Table 7). Its volatile fraction is generally 24 to 45 percent. Fat coal with a volatile fraction larger than 35 percent has a visibly lower caking characteristic than typical fat coal with a volatile fraction of 30 percent. For example, gas fat coal that generally has a volatile fraction V^r greater than 37 percent has an average coking strength M_{40} of only 42.0 percent, M_{10} averages 18.4 percent, while the coking strength M_{40} of other types of fat coal averages 71.4 percent and M_{10} averages 8.4 percent. The lower the content of the volatile fraction in fat coal the better the caking characteristic. Table 8 shows that for the types of fat coal with a y value of 26 ± 0.5 centimeters, the strength of coke M_{40} and the content of the volatile fraction of the coal are inversely proportional, but the results of M_{10} are not as obvious. The density of the colloid of fat coal with a low volatile fraction is high, and during the heating process, the coal does not easily decompose into gases but cakes with more inert components (mother of coal and minerals), and very strong coke is produced. But, the sulfur content of all types of fat coal is generally high. A lot of the fat coal produced in our nation has a sulfur content greater than 2 percent, and there are some with a sulfur content over 4 to 5 percent. It should be pointed out that the caking characteristic of fat coal is the strongest among coking coal. The strength of coke produced when fat coal is used by itself for coking is not as good as that produced by coking coal. This is because thermal stability of the colloid of fat coal is not as good as that of coking coal. When the colloid is heated, it easily decomposes and produces gases. This causes the coke produced to have many longitudinal cracks, and the bottom part of the coke is honeycomb coke. Fat coal can serve a backbone function in coking with mixed

coal. When more gas coal, blackjack and weakly caking coal are added to the coal mixture, very strong coke can still be produced. Our nation has less fat coal resources and special attention should be paid to using it rationally.

Coking coal. Coking coal is a type of coal with the best coking characteristic. When used by itself for coking, it can produce very strong metallurgical coke. The quality characteristics of coking coal are a medium volatile fraction, generally 20 to 30 percent, and a y value of mostly 13 to 25 centimeters. The coke produced by coking coal alone is strong and its wearability is good (See Table 6) The moisture content of coking coal is low. Its thermal value is high. The heat output of pure coal can reach 8,900 calories/gram. Its caking index $G_{R.I}$ is generally > 60 to 95. Its Orsat expansion value b is 0 to 200 percent (Table 7). The sulfur content of coking coal is relatively low. For example, the sulfur content of coking coal produced by the Fengfeng, Huaibei, Qitaihe, Jixi, and Hunan mines is generally below 1 percent. Coking coal is our nation's precious coal resource for coking.

Blackjack. Blackjack is a coking coal with the lowest volatile fraction. The volatile fraction is generally > 14 to 20 percent, the y value can be as low as 0 (lumps) or as much as between 5 and 12 centimeters. Its caking characteristic is relatively poor but the density of the colloid is high, thermal stability is good, and when used alone in coking, it can produce stronger and larger coke. The melting characteristics of the coke produced is not good and wearability is poor. The strength M of coke from grade 1 blackjack is large and some blackjack cannot even coke well. The strength M of coke from grade 2 blackjack averages as high as 73.2 percent, even higher than fat coal. Some of the blackjack produced by uniformly equipped coal mines now have a high sulfur content, therefore, the proportion of blackjack truly used for coking is small. The coal quality characteristics of our nation's main coking coal mines are shown in Table 9.

Table 9 Major coal quality indices of several coking coal mines

1) 矿 区	2) 原 煤 工 业 分 析				3) 灰 熔 点 (°C)		4) 精 煤 分 析		
	A ^r (%)	V ^r (%)	S _O ^r (%)	Q _{Gw} ^r (卡/克) 5)	T ₂	T ₃	V ^r (%)	y (毫米) 6)	S _O ^r (%)
7) 开 滦	15~17	28~39	0.40~2.50	5800~7000	>1350	>1500	27~40	14~40	0.4~1.8
8) 抚 顺	5~20	41~47	0.40~1.00	5900~7400	>1500	>1500	40~46	8~12	0.4~0.8
9) 淮 南	11~26	33~40	0.40~2.00	5600~7100	>1500	>1500	34~40	6~16	0.3~0.8
10) 平 顶 山	10~29	28~34	0.80~1.80	5700~7600	>1500	>1500	28~35	12~24	0.3~0.6
11) 徐 州	5~20	35~47	0.40~7.70	6400~7700	1150~>1500	1200~>1500	36~44	7~31	0.4~2.7

12) 矿 区	13) 精 煤 结 焦 性					200公斤焦炉试验 (%)		15) 煤 质 牌 号
	R.I	G _{R,1}	CSN	b (%)	G~K	M ₄₀	M ₁₀	
16) 开 滦	70~89	69~99	3- $\frac{1}{2}$ ~9	11~550	G ₃ ~G ₁₂	63~75	7~14	肥煤~气煤23)
17) 抚 顺	20~74	60~77	1- $\frac{1}{2}$ ~4	≤6	D~E	块焦少 ²¹⁾	粉焦多 ²²⁾	气煤 24)
18) 淮 南	25~80	20~82	1- $\frac{1}{2}$ ~5	≤90	D~G ₈	42~66	9.5~3.6	气煤~肥气煤25)
19) 平 顶 山	50~88	60~95	3- $\frac{1}{2}$ ~6	-10~232	G ₂ ~G ₈	64~71	9~19	气煤、焦煤 26)
20) 徐 州	39~86	30~97	1- $\frac{1}{2}$ ~5- $\frac{1}{2}$	≤208	D~G ₁₁	47~57	17~32	气煤、肥煤 27)

Key:

- | | |
|--|-----------------------------|
| 1. Coal mines | 16. Kailuan |
| 2. Industrial analysis of raw coal | 17. Fushun |
| 3. Ash melting point | 18. Huainan |
| 4. Analysis of coal concentrate | 19. Pingdingshan |
| 5. (calorie/gram) | 20. Xuzhou |
| 6. (centimeter) | 21. Less lump coke |
| 7. Kailuan | 22. More pulverized coke |
| 8.. Fushun | 23. Fat coal - gas coal |
| 9. Huainan | 24. Gas coal |
| 10. Pingdingshan | 25. Gas coal - fat gas coal |
| 11. Xuzhou | 26. Gas coal, coking coal |
| 12. Coal mine | 27. Gas coal, fat coal |
| 13. Coking characteristics of coal concentrate | |
| 14. 200-kilogram coking furnace test | |
| 15. Grades of quality of coal | |

4. Anthracite

Our nation's reserve of anthracite is also large. The main characteristics of anthracite are a large specific gravity (1.35 to 1.90), a high ignition point (370 to 418°C) which increases as the true specific gravity of pure anthracite increases. For example, the true gravity of the anthracite of Yangquan is lower than that of the anthracite of Jincheng and Beijing, and the ignition point also drops (See Table 10). The thermal value of anthracite is lower than that of coking coal but higher than that of lignite. The higher the degree of metamorphism of anthracite, generally the lower the thermal value. For example, the anthracite of Beijing has the highest degree of metamorphism, and its thermal

value (Q_{GW}^r) is 7,500 to 7,900 calories/gram while the Yangquan anthracite has a relatively low degree of metamorphism, and its thermal value reaches 8,400 to 8,600 calories/gram. The variation in moisture content in anthracite is large, from 1 to 9 percent and this increases as the degree of metamorphism increases. The melting point of anthracite ash presently produced is generally high, T_2 is generally $> 1,250$ to $> 1,500^\circ\text{C}$. Thermal stability of the coal of a few mines of Beijing and Guangdong is relatively poor (During gasification or burning, lump coal easily explodes into fragments and even pulverizes) but thermal stability of the rest of the anthracite in our nation is medium or better. The thermal stability index is < 45 percent. The thermal stability of even anthracite that has a serious explosive character can be visibly increased after preheating under a low temperature of 300°C . The mechanical strength of anthracite is mostly medium or better. The percentage of residual lumps > 25 centimeters is mostly over 60 percent, sufficient to satisfy the needs of the stationary bed gasification furnace. But the anthracite of some mines is soft and the coal stone constituencies are not easily differentiated. The mechanical strength of lump coal is very low, and the percentage of residual lumps > 25 centimeters is generally only 20 to 40 percent, and even as low as 20 percent. Activeness of anthracite frequently increases as the oxygen content increases. For example, the degree of metamorphism of Beijing anthracite is visibly higher than that of Yangquan anthracite because Beijing anthracite has a high oxygen content, therefore its activity is also higher than Yangquan coal.

For example, the CO_2 decomposition rate of the anthracite of the Beijing Chengzi Mine at 1050°C is as high as 52 to 74 percent while under the same temperature, the CO_2 decomposition rate of the Yangquan anthracite is only 12 to 29 percent. This shows that the activeness of anthracite does not drop as the degree of metamorphism increases. The quality characteristics of coal of the main anthracite mines are shown in Table 10.

Table 10. Coal quality indices of major anthracite mines

1) 矿区	W _Q (%)	A ^s (%)	V ^r (%)	Q _{GW} (卡/克)	S _Q (%)	Q _{DW} (卡/克)	8) 灰 熔 点 °C			9) 机械强度 强度解率 >25 (1050) 毫米 (°C)		K _{BTM} (%)	着火点 (°C)	热稳定性 K _P (%)	真比重 (d ₂₀)	V _T (毫升/克)	H _v (公斤/毫米 ²)
							T ₁	T ₂	T ₃								
2) 阳泉	3~8	7~18	7~10	8400~8600	0.4~1.9	5200~6300	1100~1370	>1400	>1450	60~80	12~29	0.80~1.30	367~393	12~29	1.34~1.39	270~290	31~34
3) 焦作	3~8	12~18	5~8	8300~8500	0.3~0.5	5500~7000	1200~1420	>1350	>1390	65~85	40~60	0.35~0.55	374~395	40~60	1.45~1.55	210~260	33~49
4) 北京	2~5	10~30	3~7	7500~7900	0.2~0.5	4800~6000	1040~1350	<1300	<1350	60~90	15~85	0.20~0.30	388~418	15~85	1.70~1.85	35~47	120~145
5) 晋城	4~8	10~18	5~7	8300~8500	0.3~0.6	6300~7200	1125~1410	>1500	>1500	85~90	18~45	0.40	388~404	18~45	1.50	170~210	45~55
6) 汝箕沟	1~4	4~9	6~9	8450~8600	0.2~0.3	7000~7500	1060~1215	1240	1270	70~80	43~72	0.68	382~420	43~72	1.35	258~290	41~43

Key:

- | | |
|----------------------|--|
| 1. Coal mines | 9. Mechanical strength > 25 centimeter |
| 2. Yangquan | 10. CO ₂ decomposition rate |
| 3. Jiaozuo | 11. Ignition point |
| 4. Beijing | 12. Thermal stability |
| 5. Jincheng | 13. True specific gravity |
| 6. Rujigou | 14. (milliliter/gram) |
| 7. (calorie/gram) | 15. (kilogram/square centimeter) |
| 8. Ash melting point | |

II. Main Uses of Various Types of Coal

Coal is a major energy source and an important raw material of the chemical industry. As the national economy develops, the uses of coal will become broader. Because of the different types of coal, the uses also vary greatly. The various types of industrial facilities that utilize coal can only use suitable types of coal in order to fully develop the efficiency of utilization of the facilities. At the same time, improving the quality of the product can also bring about rational utilization of coal.

A review of the varieties of coal and the supply and demand in our nation shows that over 70 percent of the coal are directly or indirectly used as fuel. To improve the efficiency of utilization of coal, to improve the rate of utilization of thermal energy, and to rationally use coal and conserve energy, we must suit measures to local circumstances, suit coal to the circumstances and consider the most economical and rational uses for the various types of coal. Here, we will separately discuss the main uses of the various types of coal in our nation in the following.

Lignite. Because lignite has a high moisture content, a high ash content and a low thermal value, it is not suitable for long distance transport. It is best suited for use by power plants near mining regions. As the output of lignite continues to increase and as the urban coal gas industry develops, lump

lignite can be used to produce synthetic raw material gas for urban coal gas by pressurized gasification to improve the rate of utilization of thermal energy. In particular, some of the lignite of the early and middle Jurassic in Nei Monggol have a very high mother of coal content and they are even more suitable for use in pressurized gasification. Lignite with an ash melting point of $T_2 < 1,250^{\circ}\text{C}$, $T_3 < 1,300^{\circ}\text{C}$, is more suitable for producing gas in the liquefied slag removal type gasification furnace. Lignite of the early Tertiary with a high ash melting point, such as the coal of Shulan and Meihe Mines is more suitable for use in pressurized solid slag removal type gasification furnace. Powdered coal < 6 centimeters can be used to produce synthetic ammonia raw material gas or fuel gas in the K-T furnace, and it can also be used to produce synthetic ammonia in the Winkler boiling layer gasification furnace. In regions that lack coking coal, lignite with a low ash content and low sulfur content can be used for coking after forming.

Lumps of lignite with a high content of tar can be used as raw material for internal heating type low temperature dry distillation furnaces. The tar can be processed to produce liquified fuel or chemical raw materials. The half coke can be used for power generation, gas production or for civilian use. Lignite has a quick reaction and a high conversion rate when hydrogenated or liquefied fuel. But the oxygen content of lignite is visibly higher than gas coal or flame coal, and when using lignite as raw material to produce liquefied products, the consumption of hydrogen is visibly more than that using flame coal or gas coal. Lignite can also be used in many types of chemical raw materials. For example, the lignite of Nei Monggol which has a low ash content and a low sulfur content can be used to manufacture activated carbon. The lignite of certain mines in Yunnan can be used to extract lignite wax, and residual coal can be made into "humic ammonium" fertilizer after debenzolization and ammonification. The humic acid sodium extracted from lignite can be used as the caking agent for pressing anthracite coal briquets used by small synthetic ammonia plants to produce gas.

Flame coal. Its thermal value and ash melting point are high. The flame is long, the mechanical strength and thermal stability are all good. Pulverized coal not only serves as fuel for power plants it can also be used in rotary kilns for firing cement. Lump coal is used as fuel for locomotives and also as raw material coal for manufacturing synthetic gas or fuel gas by the stationary bed pressurized gasification furnace and as raw material for producing coal gas for the generator furnace. Flame coal with a low ash content can be considered as a raw material coal for hydrogenation and liquefaction. Powdered coal can be used as raw material for the K-T furnace to manufacture synthetic gas. Lumps of flame coal with a high tar content can be used to produce tar and half coke by low temperature distillation using the internal heating type low temperature dry distillation furnace. Half coke can be used as civilian fuel.

Non-caking coal. Its volatile fraction is relatively high, it is active, its mother of coal content is high, its lump coal is good for gasification and a good fuel for locomotives, its pulverized coal is a very good fuel for power generation, its can be used to fire and manufacture cement in the rotary kiln, it can be used by the K-T furnace to manufacture synthetic coal gas, and

it can be used to manufacture activated carbon. Because the ash melting point of non-caking coal is low, it is most suitable for use in the liquefied slag removal gasification furnace or boiler.

Weakly caking coal. It is a better type of power generating coal. Its heat output and volatile fraction are both high, its ignition point is low, its flame is long, and its burning time is long. For example, medium lumps of weakly caking coal of Datong etc. are most suitable as fuel for locomotives and as raw material for manufacturing mixed coal gas by the stationary bed gasification furnace. Powdered coal is suitable for use as fuel for power plants and as fuel for K-T furnaces to manufacture synthetic coal gas or for use in rotary kilns to fire and manufacture cement. The weakly caking coal that has a low ash content, a low sulfur content and a good caking characteristic of the Datong Jinhuaogong Mines can be used as raw material in coal mixtures for coking after it is washed. When the coal mixture contains more strongly caking coal, a mixture with over 30 percent of weakly caking coal can still produce strong metallurgical coke of superior quality.

Lean coal. Because its thermal value is high, it is a good fuel for generating electricity and civilian fuel. Lump coal with a high ash content or a high sulfur content can be used as raw material for the stationary bed gasification furnace to manufacture fuel gas or as raw material of half water and half coal gas to manufacture synthetic ammonia after the lump coal is washed and screened. Powdered coal can be used alone to generate electricity. It can also be burned in mixture with coal with a medium and high volatile fraction so that the temperature of the flame can be increased and the burning time can be prolonged. Powdered coal with a low ash content and a low sulfur content has a good grindability because its thermal value is higher than that of anthracite and it can also be used for blast furnace blowing or sintering of iron.

Anthracite. Except the anthracite of certain mines in Beijing and Guangdong which is unsuitable for large and medium sized nitrogen fertilizer plants to manufacture synthetic coal gas because the thermal stability is poor, the anthracite of the majority of the remaining mines is suitable for the stationary bed gasification furnace in the half water and half coal gas mixture used for manufacturing synthetic ammonia. Anthracite of Jiaozuo and Jincheng which has a relatively high mechanical strength can be used as the reducing agent in iron smelting in small blast furnaces and as fuel. Anthracite powder is used in large quantities to manufacture civilian honeycomb coal and coal briquets. Anthracite with a low ash content and a low sulfur content can be used to manufacture carbon electrodes, anode paste, activated carbon, silicon carbide and calcium carbide and such high grade carbon materials. Powdered coal with a good grindability is used for blast furnace blowing.

Harder anthracite powder can be used as fuel for sinter. Lump anthracite with a relatively high ash content can be used in vertical kilns to fire cement or to fire lime. Another use of anthracite is to use it with humic acid sodium or cement, clay and such as caking agents to manufacture coal briquets for producing gas. It can also be used to manufacture coal briquets of carbonized lime.

Coal for coking. This mainly includes gas coal, fat coal, coking coal and blackjack. Some coking plants also add a fixed amount of superior quality weak caking coal. The coking of coal is one of the main processing methods for chemical utilization of coal. It is also the main way of comprehensive utilization of coal in our nation at present. Coal is used in the coking process to produce coke for metallurgy or coke for chemical engineering, at the same time, it is used to produce chemical products from coke that is important to the national economy. In industrial situations, the general production rate of major products obtained from coking one ton of dry coal is shown in Table 11:

Table 11. Production rates of chemical products from coking

1) 焦化产品	2) 产量 (公斤)	3) 产率 (%)
4) 焦炭	720~780	72~78
5) 焦炉煤气	150~190 6) (或300~340米 ³)	15~19
7) 焦油	35~42	3.5~4.2
8) 粗苯	8~14	0.8~1.4
9) 氨	2.2~2.5	0.22~0.25
10) 硫	3~6	0.3~0.6
11) 其他	3~5	0.3~0.5

Key:

- | | |
|---------------------------------|------------------|
| 1. Coke products | 7. Tar |
| 2. Yield (kilogram) | 8. Crude benzene |
| 3. Production rate (%) | 9. Ammonia |
| 4. Coke | 10. Sulfur |
| 5. Coking furnace coal gas | 11. Others |
| 6. (or 300 to 340 cubic meters) | |

Crude coal gas for coking and coal tar contain several thousand chemical components. At present, at least over 400 components have been identified. Foreign nations have already produced over 200 components industrially. In our nation, over 70 products have been produced or separated. These products are all important raw materials for the organic chemical industry. Especially benzenes, phenols and naphthalene products are major raw materials for medicine, farm chemicals, dyes, synthetic rubber, plastics and synthetic fibers. Recently, because of the ever increasing demand for coal gasification in cities, the coal gas produced by many coking plants is a very good urban coal gas source. The coke chemicals industry has already established a preliminary scale in our nation. The technology is mature, and it is economical and rational. As the national economy rapidly develops, the coke chemicals industry will develop a greater function in our nation's socialist construction. Among the coal resources used for coking in our nation, coal which has a high ash content, a high sulfur content and a poor selectability is used for

generating electricity, for powering locomotives and as fuel for other industries. Most of the remaining coal can be used in mixtures for coking after washing. Of the four major types of gas coal, fat coal, coking coal and black-jack, fat gas coal of fat coal, coking coal and gas coal are the major types of coal for coking. These types of coal should be used for coking in the chemical industry as much as possible so that they can fully develop their function. Because our nation has more gas coal resources, if we can mix in a fixed proportion of grade 2 gas coal or grade 3 gas coal in the coal mixture for coking, the production of chemical products and coal gas will visibly increase. These two types of gas coal are also the main raw materials for vertical box furnaces and Wood's furnaces to manufacture urban coal gas. In regions with more gas coal resources, the tamping type coking furnace can be used for coking to expand the amount of gas coal used and improve the quality of coke. The grade 1 gas coal has a poor coking characteristic, therefore it is mainly used as fuel to produce power. Lump coal can be used as raw material for the stationary bed coal gas generator furnace to make mixed coal gas or as fuel for curing tobacco. In addition, there is a bright future for developing gas coal with a high volatile content and a high sulfur content as raw material for hydrogenation and liquefaction because of its high hydrogen content, its low oxygen content, its high vitrain content, and its low degree of coalification.

III. Rationally Utilize Different Varieties of Coal and Conserve Energy in a Big Way

Coal is our nation's main energy source. How to rationally utilize the different varieties of coal to satisfy the needs of the various sectors of the national economy is an important consideration in conserving energy in our nation.

In 1980, our nation's thermal power plants which used a relatively large amount of coal consumed slightly less than 18 percent of raw coal produced in the whole nation. Because most of the power plants use pulverized coal boilers, if we use raw coal as fuel, the higher content of lump coal and waste rock would not produce good results. It is best to use mixed residual coal of < 25 centimeters of residual coal of < 13 centimeters in granularity or washed residual coal for generating electricity. Pulverized coal of < 6 centimeters in granularity are difficult to sieve and select and it produces a lot of coal dust during transportation and processing. A lot of coal is blown away and this pollutes the environment. If we supply lump coal, then crushing facilities must be added and electricity must be used to grind coal. This increases the cost of generating electricity and also wastes precious lump coal resources.

Each year, the amount of coal used by locomotives constitutes slightly more than 4 percent of the amount of raw coal produced throughout the nation. Locomotives use tube boilers. The stack is short, and the rate of smoke exhaust is rapid. Therefore, they require lump coal. According to experiment, a locomotive that burns formed coal or lump coal can conserve over 10 percent of raw coal. Locomotives that climb slopes greater than 1 percent can use medium and small lump coal with a granularity of 50 to 13 centimeters.

When the slope is less than 1 percent, small lump coal with a granularity of 25 to 13 centimeters can be used. When traveling on flat tracks, it is better to use coal with a granularity of 50 to 6 centimeters. Because of insufficient processing of coal, over a half of the coal supplied to locomotives for use is raw coal or mixed coal. The amount of coal blown away and lost along the way reaches 20 to 30 percent. For example, the Zhengzhou Railway Bureau used hydraulically extracted raw coal from Hebi. The amount of coal blown away was 24 percent. The Lanzhou Bureau used pulverized coal from Hami and the loss reached 50 percent. The amount of pulverized Datong coal blown away reached 15 percent. Throughout the nation each year, because the varieties of coal used by locomotives are inappropriate, over 1 million tons of coal are wasted.

The amount of coal used for synthetic ammonia constitutes 7 percent of the total amount of coal produced in the whole nation. It is best to use medium lumps of superior quality anthracite. At present, the supply of lump coal constitutes 1/3. Because the supply of coal varieties does not suite the needs, each year, more than 1 million tons of standard coal are consumed. Results of experiments conducted by the Quzhou Chemical Fertilizer Plant showed that the unit yield of a furnace burning medium lumps of anthracite of 25 to 50 centimeters was 55 tons/day but the unit yield of a furnace burning small lumps of anthracite of 15 to 25 centimeters was only 45 tons/day, and the unit yield of a furnace burning granular coal of 8 to 15 centimeters dropped to 20 tons/day. According to estimates, if the quality of ocal used for synthesizing ammonia was all above standard, then the consumption of coal can be lowered by about 30 percent.

In general, to truly conserve energy, we must improve the quality of coal and increase the varieties of coal to satisfy the ever increasing needs of each sector of the national economy.

9296

CSO: 4013/54

COAL

DATONG COAL PRODUCTION INCREASES STEADILY

Taiyuan SHANXI RIBAO in Chinese 22 Mar 82 p 2

[Article by Wang Geping [3769 7245 1627] and Yang Xiaoning [2799 1420 1380]: "Deeply Enter Into the Basic Levels; Work at the Grassroots; Solve Problems; Work on the Site"]

[Text] The various levels of leading cadres of the Datong Mining Bureau changed their work styles by entering deeply into the first line of production work at the grassroots, work on the site, and solve problems on a concrete basis. As a result, there has been a continued increase of raw coal production. By 18 March raw coal production in the entire bureau had exceeded the target by 274,000 tons.

Beginning this year, the Datong Mining Bureau has assigned 394 bureau and department level leading cadres and office personnel to enter deeply into the grassroots of 13 coal mines to conduct investigations, work with the shifts, work on the site, solve key problems of production, and assure the proper preparation and coordination of the integrated mining faces. Because of blockages in the roadways, the moving of equipment to another mining site in early February by the No. 3 integrated mining team at the Yungang Mine was delayed. The Bureau Party Committee Secretary Wang Qiufa [3769 4428 3127] and Deputy Secretary Hao Wanqi [6787 5502 4388] immediately went to the mine and went underground to examine the work site. They called a strategy meeting and mobilized the people to offer their plans. They also organized the engineering and technical personnel to make a study and a plan to solve the problem was developed. Afterwards, they rushed to the Xinzhouyao Mine to solve a problem involving two pieces of integrated mining equipment that were jammed against the mine roof. They also found that there were no personnel transport along the large 4,000-meter long underground roadway. Workers had to walk to and from the work faces. The main shaft was not heated and ice was forming on the shaft walls. As a result, the cage was unstable when traveling up and down. They immediately called a meeting to work out measures to solve these problems. In mid-February, it was found that the railroad project of the surface screening system at the Wangcun Mine was not meeting production needs, restricting the coal loading operation. Acting Bureau Chief Liu Shugui [0491 2579 6311], along with involved personnel from the capital to the site to establish a plan. As a result, the daily loading rate was increased from 50 to 80 cars and 1,500 more tons of coal could be shipped each day.

The personal efforts of the leading cadres of the bureau affected and greatly changed the working styles of the cadres of the entire bureau. During January and February, the bureau level leading cadres participated in labor an average of 5.4 days, mine and department level leading cadres participated an average of 11 days, and region and brigade cadres participated an average of 29.2 days. They all exceeded the requirements of the Coal Ministry for labor participation by various levels of cadres. The actions of the various levels of cadres to enter deeply into the basic working levels inspired the production positiveness of the 100,000 coal mine staff and workers. During January and February this year, the attendance rate of the staff and workers greatly exceeded that of the same period last year. A season of slack production was changed to one of busy production and daily raw coal output was maintained at above 70,000 tons. Currently, the third group of grassroot cadres of 74 people have gone to the first line of production.

5974

CSO: 4013/68

COAL

RAW COAL PRODUCTION IN GUANGDONG EXCEEDS PLAN IN FIRST QUARTER

Guangzhou NANFANG RIBAO in Chinese 6 Apr 82 p 2

[Article: "Raw Coal Production in Our Province Achieves Success in First Quarter; Production Plan Exceeded by 4.5 Percent"]

[Text] The coal output in our province during the first quarter exceeded the production plan by 4.5 percent. Of the total, output of provincial coal mines exceeded their overall production plan by 0.4 percent and output of local and county coal mines exceeded their overall plan by 13 percent.

Since the beginning of this year, the coal mines in our province have exercised a tight grip on production and positively adopted measures to maintain attendance and increase production. At the end of last year, the Siwangzhang Mining Bureau began to pay attention to and properly carry out its political ideological work of the staff and workers and determinedly maintained production during the Spring Festival. It encouraged hard work regularly. As a result, its coal output since the beginning of year has exceeded the production plans each month, completing the overall production plan for the first quarter 9 days ahead of time. Since the beginning of this year, the various mines have also conscientiously carried out enterprise reorganizations, established and perfected their economic responsibility systems, and raised their labor productivity. With the assistance of the working group of the Provincial Coal Department, the Hungong Mining Bureau organized 20 some people to go to its No. 1 Mine to conduct experimental enterprise reorganization work. As a result, the mine has fulfilled its production tasks month by month.

Through the improvement of management and administration, production has also developed at the bureau's other mines. Thus, the bureau completed its coal production task for the first quarter and output showed an increase over the same period a year ago. The small coal mines in the Zhanjiang, Zhaoqing, Foshan, and Haixian regions strengthened their management and administration, properly carried out technical readjustment, further perfected their economic responsibility systems, and mobilized the coal mining positiveness of the commune members. They all exceeded their first quarter production plans by more than 10 percent.

5974

CSO: 4013/66

COAL

CENTRALLY COORDINATED COAL MINES COMPLETE FIRST QUARTER

Shenyang LIAONING RIBAO in Chinese 31 Mar 82 p 1

[Article by Li Shangzhong [2621 1424 1813]: "Centrally Coordinated Coal Mines in Our Province Complete First Quarter Plan Ahead of Time; Daily Output of Raw Coal Establishes Highest Level in Five Years"]

[Excerpts] The first quarter plans have been completed 2 days early by all the centrally coordinated coal mines in the province. Production of raw coal was 7,210,000 tons, an increase of 14 percent over the same period of last year. Daily output was 1.3 percent higher than the fourth quarter of last year, establishing the highest level in 5 years. The first quarter targets for washed coal, drifting, development, and stripping were all completed 4 to 6 days in advance.

The coal mines in the province started work early in the first quarter of this year. Responsibilities were properly defined. During the last 10 days of each month, preparations for the following month's production were already completed, so that production proceeded at an increased tempo. More than a thousand cadres visited the mines in the province to take care of weak links and solve problems in production. Staff and workers in the mines pushed each other and promoted the steady increase of production levels. In March, all nine centrally coordinated coal mines exceeded their tasks. Average daily output was 9.7 percent above the plan.

Based on preliminary statistics, the labor productivity for the mines in the province on a total personnel basis was 8.2 percent higher as compared to the same period of last year. Enterprise losses were reduced by more than 11 million yuan.

5974

CSO: 4013/56

COAL

BRIEFS

SHANXI COAL OUTPUT--Taiyuan, 22 May (XINHUA)--Shanxi Province has 2,500 coal mines run by communes, production brigades or teams, producing some 35 million dun of coal a year, or one third of Shanxi's total coal output. Most of the coal produced by the locally-owned mines are shipped to other localities by truck. Provincial departments concerned urged local authorities to organize all available trucks to facilitate coal shipment and avoid excessive stockpiling. [Beijing XINHUA Domestic Service in Chinese 0150 GMT 22 May 82 OW]

LIAONING COMMUNE COLLIERIES--Commune- and brigade-run collieries have developed well in Liaoning Province in the past few years. At the end of 1981, the number of commune- and brigade-run collieries in the province increased from 84 in 1971 to 270, and the annual raw coal output increased from 720,000 tons in 1971 to 2.3 million tons, netting 7 million yuan of profits. In March 1982, some 500,000 yuan of funds and 200,000 yuan of interest-free loans were allocated to 246 commune- and brigade-run collieries to help them get additional equipment and improve mechanization. [Shenyang Liaoning Provincial Service in Mandarin 1100 GMT 4 Apr 82 SK]

HEILONGJIANG COLLIERY READJUSTMENT--Heilongjiang Province has made considerable headway in readjusting the collieries whose products are distributed under the unified state plan. As of the first quarter of 1982, over 70 percent of all mining projects were readjusted. According to statistics compiled at the end of April, total raw coal output was 600,000 tons above the plan and the tunneling footage was 4,585 li over the planned figure. By the end of 1981, after a 3-year readjustment period, 20 readjusting and renovating projects were completed and put into operation. The 42 pairs of mine pits existing before the readjustment were merged into 27 pairs, but the annual production capacity increased 40 percent. Total provincial raw coal output increased by 12.09 million tons over the record in 1975, increasing at an average amount of 2.01 million tons a year. At the same time, these collieries built 740,000 square meters of housing for workers and staff were 147 yuan more than in 1978. The readjustment of these collieries will be completely finished in 1983. [Harbin Heilongjiang Provincial Service in Mandarin 1100 GMT 16 May 82 SK]

HEILONGJIANG COAL RESOURCES--According to information released by the recent Heilongjiang provincial work conference on investigating and appraising coal resources, the province is rich in coal resources. This year the state will organize a scientific and technological force to conduct an overall investigation. China ranks fourth in the world in coal resources. The province's coal reserves account for two-thirds of all coal reserves in China and most have not yet been exploited and utilized. Last year a coal deposit with a reserve of some 3 million tons was discovered in Dede County. [Harbin Heilongjiang Provincial Service in Mandarin 1100 GMT 17 May 82 SK]

COAL PRODUCTION--Beijing, 12 May (XINHUA)--China's coal industry has surpassed state production goals every month this year, and the nation's total coal output in the January-April period was 12 percent over the same period of last year, according to Yu Hongen, vice minister of coal industry, who addressed a national telephone hookup on coal production here this evening. The January-April output of the coal mines managed by the ministry of coal industry was 9 percent over the same period of last year, and the average daily output reached 965,800 tons -- 76,500 tons more than that for the same period of last year. The tunnelling footage and output of dressed coal all surpassed state targets, he said. The vice minister said that leading cadres at all levels had improved their style of work and more people had joined production at the coal faces. [Text] [Beijing XINHUA in English 1527 GMT 12 May 82 OW]

PLANNED COAL PRODUCTION EXCEEDED--Plans for raw coal production for the first quarter were exceeded ahead of time by the eight coal mines under the Provincial Coal Department, including Yipinglang, Yangchang, Tianba, Housuo, and Laibin. Success by every mine was achieved. The entire system completed its plan 9 days in advance. Total raw coal production in the first quarter exceeded the quota by 13.7 percent while development work exceeded the quota by 17.5 percent. Compared to the same period last year, they represented increases of 30.8 percent and 39.1 percent respectively. [Text] [Kunming YUNNAN RIBAO in Chinese 3 Apr 82 p 1] 5974

CSO: 4013/56

HUGE LIGNITE FIELD SURVEYED--A detailed geological survey of what is now China's largest Tertiary lignite field--The Zhaotong lignite basin--was completed at the end of last year [1981]. The survey determined that there are some 7.92 billion tons of lignite that could be used by industry. The Zhaotong lignite basin covers an area of approximately 230 square kilometers, including the coal-bearing area of some 140 square kilometers. The field, which lends itself to open-pit mining, has a depth of more than 180 meters with an average yield of 1 ton of coal per 2 cubic meters of material extracted. [Text] [Kunming YUNNAN RIBAO in Chinese 19 May 82 p 1]

CSO: 4013/91

STATUS, PROSPECTS OF PETROLEUM GEOCHEMISTRY IN CHINA REVIEWED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 2
No 4, 1981 pp 388-389

[Article by Huang Difan [7806 4574 5672], Beijing Scientific Research Institute of Oil Exploration and Development: "The Current Status and Prospects of Petroleum Geochemistry in This Country as Indicated by the Second Annual Meeting of the China Petroleum Society"]

[Text] Thirteen papers on petroleum geochemistry were read and discussed at the oil generation session of the second annual meeting (1981) of the China Petroleum Society. They dealt with: the structure of oil-producing matrices and with methods and diagnostic features for distinguishing types of organic material; mechanisms, modes and thermal reaction kinetics in the evolution of organic matter; the study of biological marker compounds (porphyrins, perylene, sterane, terpane and the like), and their use in comparison of oil sources; indicators for evaluation of oil-generating rock and methods of estimating and computing oil generation; time-temperature indices (TTI); and new methods such as laser thermolysis spectroscopy and the like and their applications in the study of petroleum constituents. Although the number of papers presented was not large, they were selected from more than a hundred that were submitted and are fairly representative of our country's research in the petroleum generation field.

Because of the "ten catastrophic years," it was not until 1977 that our country's petroleum generation research began to revive in response to the developing needs of the petroleum industry. During that 10-year period, foreign analytical techniques and theory made great advances, producing the kerogen thermal decomposition theory of oil generation and many new oil-generation evaluation indices and molecular coefficients, and establishing further correlations between petroleum and source rocks, while our country essentially remained stagnant at the 1960's level. As a result, at the first annual meeting of the petroleum society (1979), many of the papers dealt with "importation" of new concepts, new theories, new methods and new testing techniques for use under our country's geological conditions, particularly in connection with continental facies deposits. In recent years, petroleum geochemistry research in this country has received widespread attention and has developed rather rapidly. As a result, many of the papers presented at this annual meeting showed clear progress in terms of both technical standards and profundity

of research, and there was much pioneering work; our Chinese specialists are beginning to make contributions again in the field of organic geochemistry. Some examples are presented below.

1. The characteristics of the oil-forming evolution of organic matter in our major oil and gas basins and the oil-formation modes involved have been established and further characterized, and various practical indicators have been used to determine limiting depths and temperatures for oil formation with some accuracy. Such work has been carried on in the Daqing, Shengli, Dagang, Renqiu, Liaohe, Miyang, Jiangnan and Tsaidam areas, among others.
2. A deeper understanding of the conditions under which the various new organic geothermal indicators can be applied in continental-facies strata has been achieved, and some new concepts and indicators have been proposed, including the distribution and environmental significance of odd-even predominance (OEP), even-odd predominance (EOP) and the carbon predominance index (CPI); the distribution and evolution of the phytane series; the use of various aromatic structure indicators to discriminate petroleum-generating rocks and degrees of maturation; differentiation of kerogen types; and carbon isotope measurements and studies.
3. In recent years the relevant units in this country have been continuing research on biochemical marker compounds such as cholestane, singly and doubly aromatic cholestane, tricyclic and pentacyclic terpanes, porphyrins and perylenes, and a relatively high standard of research has been attained. In these investigations a series of already-known and new molecular coefficients have been used to identify matrix rock types, degrees of maturation, and evolution characteristics and stages, the pregnane evolution mechanism, has been proposed and the complete tricyclic terpane (C_{16} - C_{28}) series (which appears in late stages of maturation) has been discovered, solving the problems of differentiating certain oil regions and oil sources.
4. In order to meet the need for express analysis, in the past 2 years there has been new progress in pyrolytic analysis and data processing, new diagrams for distinguishing kerogen types have been presented, and it has been discovered that the lower extent of the oil-formation liquid state window is the gas-liquid critical point, thus laying an excellent foundation for rapid evaluation of oil-generating rocks. In addition, investigations on the use of laser thermolysis to study oil generation have begun.
5. Investigation of the mechanisms of oil-gas drive (including the evolution of clay mineral associations and effective drive thicknesses) and research on parameters and computation methods in quantitative evaluation of oil generation have also made gratifying progress, furnishing computation principles and formulas for thermochemical kinetics, thermolysis data and mathematical modeling, which will effectively promote resource evaluation work.
6. Other progress includes the application of the TTI at Daqing oilfield. The study of light hydrocarbons in oil-generating rocks, the analysis of oil matrix structure in continental facies, and measurement of carbon isotopes and free radicals, among other activities, have reached or soon will reach advanced levels.

The studies described above not only have accumulated rich data for organic geochemistry, discovered some new laws and promoted the development of the field, but also have provided much direct evidence on the generation of oil in continental facies. Currently, petroleum organic geochemistry is having a steadily increasing effect on our country's exploration and development of its oil resources, has attracted increasing attention and interest and has become a powerful means of estimating the basic oil-gas prospects of a given region. In addition, various types of instruments and equipment have now been put into use in analytic experiments in organic geochemistry, essentially satisfying current research needs.

We have made excellent progress and the gap between our work and the state of the art abroad has been decreased. It may perhaps be said that we have reached a stage equivalent to the state of the art in the 1970's and are now moving forward with out petroleum geochemical research. This is very gratifying, but there still exist some weak links and areas awaiting development, and there are still considerable gaps in experimental techniques, to which our country's petroleum geochemistry workers must apply joint effort.

1. The study of oil generation in carbonate rock is an extremely weak link. Among the papers submitted to this yearly meeting, only very few dealt with the organic geochemistry of carbonate rock and its evaluation, and many fundamental questions still remain unclear. Carbonate rock occurs extensively in our country, but its organic content is generally very low and it is generally rather highly metamorphosed, its structure is rather complex, and the questions of how to estimate its oil-gas potential and how to go about effective exploration urgently await solution for current oil-gas resource evaluation purposes.
2. As petroleum organic geochemistry develops, the quantitative evaluation of source rocks not only is needed for production but is a potentially solvable problem. In other countries this topic is generally in the realm of "corporate secrets"; little has been published on it, and what has been published is not necessarily useful. Research in this country has made an excellent beginning, and even better achievements may be publicized at the next session, providing effective guidance for resource evaluation work.
3. Many problems involving source rock evaluation indicators, thermal evolution indicators, type indicators, and kerogen formation and structural models merit more thorough research so that we can gain a further understanding of the mechanism of oil formation and refine continental-facies source rock evaluation.
4. Further improvement of techniques for thermolytic express evaluation and analysis of the formation of thermolytic products not only would stimulate research in kerogen geochemistry, but would also be extremely beneficial for resource evaluation. Geochemists are engaged in efforts in this area; they have already achieved respectable results, and further progress may be expected in the future.

Petroleum geochemical simulation experiments still are a weak link in our country's research work, and even though some work has been done in the mechanisms of oil and gas drive and in the kerogen thermal model of oil formation, we are still rather far behind foreign countries and must intensify our efforts. It must be realized that this is an essential aspect of organic geochemical research which will help discover the essence and the mechanisms of many geochemical phenomena and explain some problems in thermal reaction kinetics.

6. The investigation of biochemical markers and the use of a series of relevant molecular coefficients will be an important area of petroleum organic geochemical work in the 1980's; some current geochemical indicators will be replaced by such molecular coefficients. Clearly, the geochemical effects of organic matter will be reflected even more sensitively in the distributional and structural changes of these special series of molecules, and accordingly the relevant geochemical indicators will become even more precise. This is a developmental trend which should have the attention of all geochemists in our country.

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CSO: 4013/37

MESOZOIC-CENOZOIC CONTINENTAL OIL-GAS BASIN CHARACTERISTICS ANALYZED

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 2 No 4, 1981 pp 314-309]

[Article by Guan Shicong [7070 1102 5115], Wang Sheng [3769 0524], Zhang Shaowei [1728 4801 4850], Yuan Jie [5913 2212], Yuan Fengtian [5913 7364 6879], Jiang Shengbang [3068 5110 6721], Xu Mingguang "6079 7686 0342] and Cheng Xiaodong [7115 2556 2639], Office of Oil Exploration and Prospecting, Ministry of Geology; "Some Questions in the Study of Mesozoic and Cenozoic Continental Oil-Gas Basins in China"*]

[Text] As our country's petroleum geology surveying and exploration work expands, the study of Mesozoic and Cenozoic continental oil-gas basins is becoming more profound. Research work is based on a certain theory of structural geology, and the introduction of new structural theories will provide a stimulus to our thinking and make research more profound. But it should also be realized that the structural theories of the various schools often stress particular structural phenomena or characteristics and neglect the large quantity of geological data that has been accumulated in the process of surveying and exploring numerous continental basins and the common features which these data indicate in many basins. Experience makes it clear that the geological structure, stratigraphy and oil-gas content of some of our country's large, medium and small oil-gas basins have characteristic features. Further investigation of the mechanisms of formation and laws of development of basins and their classification and comparative study, the study of sedimentation modes and basin-formation and oil-formation periods, and the conduct of long-term forecasting and evaluation are essential to continental expansion of the number of known oil fields (or pools) and discovery of new ones in continental basins.

1. The formation and development of our country's Mesozoic and Cenozoic continental oil-gas basins clearly involved a number of stages. Different theories divide up the stages of basin development in different ways.

*This article presents some opinions of the group on "Research on the Periods of Formation of Mesozoic and Cenozoic Gasins and Oil in China"; the views presented have not been systematized or finalized and are published to attract a response as guidance for our specialized work.

For example, some stress differences in the scope of deposition in different periods, dividing the basin development process into an initial relatively small-scale formation stage, followed by a development stage involving expansion to a relatively large scale, then a contraction stage in which the scope of deposition clearly decreased. Other theories focus on differences in the types of material deposited at different stages, dividing the development process into an ocean-bay basin stage, a lake basin stage and an alluvial-plain basin stage in terms of concepts of sedimentary facies or formations. Still other theories divide the basin development process into a fault depression stage, a downwarp stage and an infilling stage in terms of the controlling effect of different types of structures on the basins. Further theories distinguish different stages of development in terms of other factors and a variety of circumstances. Our viewpoint is that the distinguishing of stages in basin development should be based on certain important "tectonic episodes" which can generally be compared over a relatively large geographical area (although such comparisons are rather controversial at present). These important "tectonic episodes" controlled and differentiated the characteristics of different stages in the development of our country's Mesozoic and Cenozoic continental oil-gas basins. Accordingly, research focused on various characteristics of the different stages of basin development will produce a correct comparison of the effects on basin formation, development and disappearance produced by tectonic episodes and certain tectonic movements which separated them. We believe that in the long stream of geological history, the multi-stage nature, cyclicity, intermittency and multiplicity of tectonic movements imply a temporal analysis of the interaction of worldwide periodic and simultaneous crustal changes, and the succession of more or less stable and more or less mobile stages. These circumstances show up particularly clearly in our country from the Late Triassic on, when a new stage of continental basin development begins. The tectonic episodes cannot be uncritically treated as catastrophic turning points. Similarly, the long periods between tectonic movements cannot be treated as absolutely static. We emphasize strongly that stability and mobility are relative terms, but that different stages of basin development differ both qualitatively and quantitatively. We distinguish vertical formational and structural relationships between different stages in the study of development of Mesozoic and Cenozoic continental oil-gas basins in this country.

2. Once we have compared the development of the various basins, we can arrive at a clear conception to the effect that a given geological period or a specific tectonic episode, or a structural period consisting of a number of episodes or a number of structural stages, is in a horizontally, i.e. spatially, mutually constraining relationship with individual tectonic stress fields and particular boundary conditions, and thus governs the distribution, formation, development, state, type, evolution and disappearance of basins and the characteristics of sedimentation and mineral formation (particularly coal and oil formation), and that similar stress effects can produce similar basins and different stress effects must produce different types of basins. Extending this view, even in different stages or different periods, similar stress fields and boundary conditions can produce similar basins, while different stress fields and boundary conditions in the same stage or period must produce different basin types. Stated in general terms, structural movements in different episodes or inter-episode stages which differ in nature and degree will, if they produce different

stress effects over time, lead to the formation of different stress fields; but spatial similarities (or differences) in tectonic stress fields or boundary conditions inevitably produce similar (or different) kinds of basin development and distribution. This is the basic concept which we use for classifying Mesozoic and Cenozoic continental basins in our country and for investigating basin-formation and oil-formation periods.

3. In recent years we have addressed the question of continental Mesozoic and Cenozoic petroleum stratigraphy in China. This is one of the fundamental topics in the study of continental Mesozoic and Cenozoic oil-gas basins in this country. Although we did not give a precise definition of the term "petroleum stratigraphy," as the first two sections of this article indicate, the temporal and spatial relationships between developing basins determine and control basin stratigraphy. All factors contained in the strata, i.e. lithology, lithofacies, cyclicity, structure, paleontological characteristics and stratigraphic contacts, constitute the physical manifestation of a specific sedimentary body resulting from basin formation and development in a specific stage of earth history (also called tectonic stage or tectonic period). The fundamental content of petroleum stratigraphy should include the different formation characteristics of different basin types, the laws of their vertical and horizontal transformations and comparative features, and their relationships to oil and gas formation, migration, accumulation and redistribution. Clearly, whether we are talking in terms of deposition sequences and deposition cycles or in terms of sedimentary associations, sedimentary markers and sedimentary strata, but especially if we are seeking a connection between stratigraphy and oil-gas content, we must also keep aware of paleontological stratigraphy, structural stratigraphy, period stratigraphy, lithological stratigraphy and earthquake stratigraphy and of the laws of igneous activity in the various stages in our study of the formation characteristics and oil-gas content of different basins, in addition, we must go on to distinguish and compare the transformations and interrelationships of basin types and basin deposits in spatial and temporal terms in order to evaluate their oil-gas prospects.

The study of petroleum stratigraphy also must deal to a greater extent with the modes of basin formation and development and with deposition modes for different basin types, as well as with their relationships to oil and gas formation. On the basis of existing data we can reach the clear conclusion that as a result of differences in the structural movements that formed basins belonging to different temporal stages, and to differences in basin types over time resulting from differing stress effects and boundary conditions, the deposition modes for different basin types will have specific characteristics and will be closely related to oil-gas content and to specific oil-formation periods. The oil content of basin deposits is primarily dependent on the oil-formation characteristics of different strata (i.e. specific oil geochemical indices) and the nature of their associated reservoir strata and cap strata; in addition it depends on the characteristic association of strata in a given deposition mode. Accordingly, the study of oil-source, reservoir and cap strata combinations in terms of stratal associations and oil-gas prospects is the main component of petroleum stratigraphy.

4. The tectonic position and basement rock character of basins constitute important boundary conditions affecting their development, but they are not the only or the critical factors. These boundary conditions change from stage to stage in response to temporal development and spatial distribution, and the characteristics of the geological bodies which function as the foundations of basins or which have an effect on them are not fixed and unchanging: thus the geotectonic distinction between stable and mobile belts is relative. Accordingly, so-called craton basins merely develop on stable blocks during a certain stage, but this does not mean that they are permanently solid and stable; and the structural forms present during or after their period of formation are not always and eternally faults, grabens and rift valleys.

Naturally, the so-called "craton basin stratigraphic model" has considerable diversity. Similarly, so-called "active belt basins" which have undergone one or more tectonic episodes and become stable basins are also called craton basins, but to confine development during and after basin formation to the fixed category of "stable" development is obviously unrealistic. Numerous Mesozoic and Cenozoic basins in the eastern part of our country have been called craton basins, and advocates of plate tectonics in particular press this view, but the development of these basins included several relatively mobile and relatively stable stages and different types of structural movements, so that the sedimentation modes of the different basin development stages follow an overall pattern but also have unique characteristics. Chinese continental Mesozoic and Cenozoic basins are of either "superimposed" or "uniform" types. The term "superimposed" refers primarily to cyclic superimposition of various sedimentation formations and tectonic cycles in different stages; while the term "uniform" refers to sedimentation formations and structural cycles from a single stage. The former category includes the latter, so that the development of basins of "uniform" character is a form of development of "superimposed" basins. Accordingly, "superimposed basins" really embody the development of different basin types or the multistage nature of basin development; the temporal and spatial interrelationships of the different stages have specific characteristics. This "uniform" or "superimposed" sedimentary combination of sedimentary modes in different geotectonic positions or different historical periods is an important datum for evaluating the oil-gas content of basins.

5. We assert that the multistage nature of basin development distinguishes relatively stable and relatively mobile types of tectonic movements and corresponding effects on basin types and sedimentation (this refers purely to temporal changes). In relative terms, tectonic movements are either active or stable. We believe that in stages where tectonic movements are relatively intense, active horizontal stress effects predominate, and that the associated cyclic magmatic and basin development stages and developments all clearly have specific strain patterns, for example linearly arranged trough basins, or volcanic flows in a certain direction; while in stages where tectonic movement is relatively stable and static, the corresponding basin subsidence effects are clearly apparent and positive structural areas surrounding the basin lack corresponding large-scale violent uplift, but are continuously eroded and leveled, and some parts of them are gradually captured by the basin, forming a depression or non-trough basin. The "mirror reflection" between the basement planes of the large and medium-size continental Mesozoic and Cenozoic basins in our country

and the Mohorovicic surface can be considered a manifestation of the deformation of matter in the deep crust below the basins, but they are the result of equilibrium adjustments (or equilibrium compensation) when stages of violent activity resulting from tectonic movements pass into static, stable stages. Accordingly, in static, stable stages of basin development, this "equilibrium compensation" has an important controlling effect manifested as spontaneous vertical subsidence of the basins, generally producing open basins with extensive development of stratigraphic bodies favorable to the formation of oil and gas.

Thus, in stages of relative activity and relative stability, the mechanisms by which regional tectonic movements produce basins are not completely identical. But whether they are produced by horizontal or vertical stress, the strain patterns formed under specific boundary conditions are subject to specific laws. In addition, because of differences in boundary conditions, within a given tectonic stage there may be differences in strain patterns produced by the same stress effect. For example, the late Triassic was expressed in Sichuan and the Ordos by the occurrence of an "open basin," i.e. a large-area depression or downwarp, while east of this was an area of relative uplifting, and although there is some occurrence of the upper Triassic series there, there are no extensive open-basin sediments. In the late Jurassic to early Cretaceous, tectonic movements were relatively vigorous and horizontal movements predominated, with the result that in the eastern part of our country there appeared some north-south trough depressions and other structures of various orders: for example, the north China, Yangtze-Han and the Sichuan and Ordos depressions contracted. In the late Cretaceous, open-basin sedimentation occurred in the Songliao, Ordos, eastern North China, Jiangsu, Yangtze-Han, South China and south Yellow Sea regions; the Songhuajiang group in the Songliao Region is currently our country's main oil-containing stratigraphic group, and we may infer that our country's extensive northwestern deposits also have open-basin sedimentary characteristics. In the early Tertiary, extensive trough basins occurred in areas of the eastern part of the country, including Hubei, North China (including the Liao River) and the Bohai, the southern Yellow Sea, while the Songliao basin and the Sichuan basin tended to contract and disappear.

The evidence cited above shows that in different structural stages, under different stress influences and with different boundary conditions, consistent strain patterns were produced but with their own specific characteristics. In terms of the multistage nature of basin development and the laws of basin distribution, there are a great many modes of development of our country's continental Mesozoic and Cenozoic basins; they cannot all be classified as "superimposition" basins or simply explained by the "fault depression filling--depression cover--uplift depression" process. We assert that at a given temporal stage, the nature of tectonic movements is different in different areas, and when there are spatially equivalent stress fields but different boundary conditions, the stress situations differ, so that in a given period the circumstances of depression development may be diverse and not in balance. Conversely, in the "superimposition" process, because boundary conditions differ, every stage has different basin formation circumstances. Trough basins may have a long-continuous period of development, but sometimes after a brief period of development they disappear rapidly; open basins may continue to

above trough basins, but sometimes they occur independently over different types of basements. We believe that the "superposition" process and "super-imposed" differ with location. Accordingly, studying the history of our country's continental Mesozoic and Cenozoic basins involves in particular the question of periods of basin formation and oil formation, and we assert the dialectic viewpoint that they are both uniform and contradictory, both temporally and spatially, in order to remake the multitype development model.

6. Chinese and foreign investigators classify basins in many different ways. Relying primarily on the dialectical space-time relationships of basin development, we start by distinguishing the two basic types, namely trough basins and open basins. These two large basin types have different origins and paths of development, and their sedimentary formation and late transformations also differ. The study of their sedimentary characteristics and deposition modes is extremely important for evaluating basin oil and gas content.

The first category is that of trough basins. For example, the Late Triassic, Late Jurassic--Early Cretaceous, and Early Tertiary trough basins have the following geographical characteristics.

a. They develop deposits and formations which indicate rapid subsidence, such as sandstones containing large quantities of clastics, flysch-like structures, sediments with turbidity current characteristics and the like. Trough basins generally have rapid deposition rates.

b. In a group of relatively small trough basins like the Fouxin basin, basin subsidence was compensated relatively fast, sometimes producing a "super-saturated" state; these basins generally lacked broad deep-water facies zones, marginal facies were either absent or relatively narrow, and reducing conditions were relatively limited. But large amounts of near-shore terrigenous organic matter was rapidly subjected to deep burial in these basins, or when the reducing effect was insignificant, coal-bearing formations were generally deposited. In another type of relatively large-sized trough depression, including grabens, dustpan-shaped depressions and the like, such as those of North China and Subei, there sometimes was rapid subsidence and insufficient compensation, producing a "starved" state with excellent reduction and trap environments which were favorable to conversion of organic matter to hydrocarbons, and oil-gas and gypsum-salt formations were deposited.

c. Isotope dating of Mesozoic and Cenozoic magmatic rocks indicates that the period of maximum magma activity corresponded with the period of accelerated basin subsidence.

d. Depositional interfaces are relatively frequent along the marginal areas of basins. The tectonic episodes distinguished by these interfaces manifest the multifrequency character of structural movements during periods of trough basin development.

e. Trough basins are frequently narrow and elongated with pronounced directionality. They frequently show clear correspondence with neighboring coeval

orogenic belts, uplift belts or other structural belts, and their edges are frequently controlled by fixed structural elements such as faults, so that they are occasionally called "structural basins" or "fault depression basins" and the like; but sometimes they are geosynclinal. The locations of facies belts within the basins and of certain structural belts of early date within them also agree with the directions of regional structures of arc in a clear mutually conditioning relationship with them.

The other type of basin has been called the "open basin" type; examples include many non-trough basins of the Late Triassic, Middle and Late Cretaceous, and Oligocene, which have the following geological characteristics.

a. They generally begin with sedimentary molasse-type red clastic members, gradually passing over into sandstone and siltstone deposits produced under stable conditions and rather thick melanocratic mudstone and slate deposits. The sandstone is of simple composition, consisting primarily of quartz sandstone and arkosic quartz sandstone. Accumulation rates are rather slow.

b. In the process of development toward a stable condition in open basins, material source areas are gradually eroded and leveled, equilibrium and compensation effects gradually weaken, the speed of subsidence gradually exceeds the rate of accumulation, and the basin develops to a "starved" state; deep-water facies zones appear, providing a reducing deposition environment which is favorable to oil and gas production and redistribution. The basins' marginal facies zones are broad; and some transitional facies zones such as delta facies and beach facies are well developed.

c. Isotope dating of Mesozoic and Cenozoic magmatic rocks indicates that the periods of stable development of open basins are also periods of weakening or cessation of magma activity.

d. The stage of stable development of open basins involves primarily subsidence movements, earth pulsations are frequent, sedimentation cycles are clearly apparent, sedimentary series are generally continuous, and overlap of the strata is evident, but pronounced, large-scale sedimentary interruptions or discordancies are rather infrequent.

e. Open basins generally take in large areas. Because of crustal subsidence and overlap of sedimentation, different structural units are frequently included in open basins. This speaks powerfully in support of the idea that the development of open basins can be "superimposed" on trough basins and also can proceed outside of trough basins. Open basins should not be limited to a trough basin foundations and should be fundamentally distinguished from trough basin development. Many large and medium-sized oil and gas basins in our country developed on a nonuniform basement of varying character. The formation of open basins involves characteristic boundary conditions which are not entirely the same as those of the trough basins they may succeed; the boundaries of open basins are seldom or never controlled or affected by certain regional structural belts, so that their formation is not entirely regular, but late structural movements separate or dissect them, resulting in oval, rectangular or prismatic external outlines and different directional orientations.

In general terms, open basins still preserve their initial shapes to varying degrees, differing from trough basins in being relatively broad. Open basins are sometimes called "depression-fold basins", "subsidence basins" and the like.

7. Summarizing and analyzing the geological characteristics of these two types of sedimentary basins makes it possible to establish sedimentation modes for our country's Mesozoic and Cenozoic continental basins and make a further analysis of their controlling effect on oil-forming series. On the basis of preliminary discussion, we focus on the following.

a. Different types of oil-producing rock have characteristic places of occurrence, both horizontally and vertically, in different types of basins and in different stages of basin development. For example, sapropelic oil-producing rocks are deposited in the middle and upper sections of open basins and in deep-water conditions in subsidence centers; humic coal-containing structures predominate in the near-marginal facies of small trough basins and in their cyclic middle and lower sections; and oil-producing series predominate in subsidence centers of larger trough basins and in their cyclic middle and lower sections.

b. Different types of sedimentary basins have stratigraphic series and facies zone distributions corresponding to different sedimentation modes, and their own characteristic distributions and combinations of oil-producing, reservoir and cap strata. Examples include: stable deposition of deep-water lacustrine-facies melanocratic mudstone and shale, development of perfect delta systems, and the existence of alluvial plains, in open basins; the various oil-producing and coal-producing combinations rich in organic matter and formed by rapid burial in trough basins; and the intercalation of marine facies. All of these phenomena are closely associated with the nature and development of basins.

c. Different basin types and different deposition modes have different geothermal gradients; there is a distinction between "hot" crust and "cold" crust. Deposition modes also generally embody the effect of nonuniform sediment thickness on geothermal gradients. Geothermal gradients directly control oil-formation boundaries and coal-producing effects. Coal metamorphosis effects following coalification are even more closely associated with geothermal phenomena. Accordingly, we believe that studying the genetic relationships of different deposition modes to primary and secondary oil formation is of important practical significance.

Only combining the content and conceptions of the research topics described above and further analyzing the relationship of first-rank and sub-first-rank tectonic traces in basins to oil formation processes will enable us to gain a clear understanding of basin-formation and oil-formation periods in the Mesozoic and Cenozoic in China and to use this understanding for comprehensive evaluation of Mesozoic and Cenozoic oil and gas prospects in China.

SUPPLEMENTAL ENERGY SOURCES

PROVINCIAL GOVERNMENT SUBSIDIZES METHANE PIT CONSTRUCTION

Guangzhou GUANGZHOU RIBAO in Chinese 19 Mar 82 p 1

[Article by Staff Correspondent: "Provincial Government Accelerates Methane Construction; Suburb Region Subsidizes Each Household With 100 Yuan To Encourage the Masses To Work on Methane"]

[Text] Recently, the Provincial People's Government made its decision requiring concerned departments, counties, and regions to strengthen their leadership for methane construction in the rural areas. It asks for proper planning and active promotion of the family-type methane-generating pit in accordance with local conditions and calls for the realization of notable results within 2 to 3 years.

At present, there are over 500 methane-generating pits in our municipality. The Kengkou No. 1 Brigade of the Hedong Commune in the suburbs already has over 30 low pressure methane-generating pits in its village. In addition to the use of methane as the source of fuel for cooking the three meals of the day, each family also uses the gas in cooking food for the pigs and in raising decorative fish. The use of the gas is simple and is welcomed by the masses.

The rural areas in our municipality are extremely short of fuel. Large quantities of crop stalks are burned as fuel and a great deal of the branches and leaves of trees in the mountain and hilly regions are also destroyed. Consequently, various levels of leadership must improve the understanding of methane construction and enthusiastically support the peasants in methane construction. The suburb region plans to use the Hedong Commune as the key area and assigns a person specially responsible in seeing that one or two villages will be completely changed to the use of methane this year. Altogether 400 new methane-generating pits will be constructed in the region. At the same time, some appropriate collective pits will also be constructed. The plan calls for the construction of a total of 800 pits in the region within three years. As an encouragement to commune members to develop methane themselves, the suburb region government has decided that for those who wish to construct pits themselves each household will be subsidized with 100 yuan, 1,000 jin of cement, and 70 jin of reinforcing steel for pit construction. The counties of Fanyu, Zengcheng, and Conghua all plan to vigorously carry out the construction of methane demonstration projects. The Municipal People's Government requires the people's government of each county and each region to include methane

construction in its daily agenda for discussion, to establish a regular organization to handle the methane construction matter, and to include in its plan and conscientiously solve the requirements for funding and material subsidies for pit construction. Special funds earmarked for the development of methane-generating pits cannot be used for other purposes. At the same time, propaganda and research departments should also include methane work in their plans to properly publicize and expand the work. Methane construction in the rural areas of our municipality must be afforded greater development.

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SUPPLEMENTAL ENERGY SOURCES

GUANGZHOU PROMOTES COMPREHENSIVE USE OF METHANE

Guangzhou GUANGZHOU RIBAO in Chinese 23 Apr 82 p 1

[Article: "Promoting Comprehensive Use of Methane With Feet Solidly on the Ground"]

[Text] Methane is one of the important energy resources in the rural areas. The provincial and municipal party committees have advocated the promotion of methane use for many years. What is the current status in the use of the methane energy resource in the rural areas of our municipality? Based on the materials we have gathered, our conclusion is: "Benefits are notable but popularization is slow." Methane in the rural areas is far from being fully utilized.

Saying that "benefits are notable" refers to the fact that some of the rural areas in our suburb and Fanyu counties have advanced from collectively developed methane-generating pits to both collectively and individually developed methane-generating pits. The use of methane has advanced from the single utilization of the past to comprehensive utilization. Currently, there are 579 methane-generating in the entire municipality, including 197 collective pits and 382 peasant household pits. In addition to providing fuel for cooking the three meals of the day, the commune members also use methane for heating, the raising of fish, lighting, curing of food, development of mushroom production, etc. The masses have concluded that there are seven important benefits in the utilization of methane: conservation of energy resources for the state, improvement of fertilizer quality, saving of fuel expenditures, purification of rural environment, beneficial to multiple enterprises, reduction of household labor, and maintenance of ecological balance.

Saying that "popularization is slow" refers to the fact that the use of methane in our municipality is only limited to some individual communes and brigades and is far from being promoted to the large rural areas. The number of methane-generating pits constructed in our municipality is only about 0.1 percent of the more than 442,000 households in all the rural areas of our municipality which are short of firewood. Furthermore, most of them are old pits constructed before 1978. Many of them still have problems, with intermittent stoppage and even long periods of shutting down.

Why is the use of methane not popularized in the rural areas of our municipality? There are three reasons. First, since the "big leap forward" we have

engaged in two "mighty mass movements to develop methane." For their propaganda work, there was a tendency for exaggeration. Thus, "when falsehood is told as truth, truth is taken as falsehood." In the actual practice, the masses discovered that it was not as wonderful. This created a bad reaction. What started in great enthusiasm dissipated in a hurry. Secondly, in the development of experimental centers for popularizing methane utilization, the comrades did not consider objective conditions. This resulted in failures and directly affected the popularization work. For instance, the area occupied by the Dongwan Brigade, Xinhua Commune, in Hua County is a grain production region. There is little hog breeding and the population does not have the habit of using wet fertilizer. (The masses are used to using dry hog manure powder fertilizer and hog manure is directly applied to the fields.) The concerned departments did not consider these objective factors. In providing public funds, public materials, and technology, they "officially developed" 263 methane-generating pits. As a result, these pits depended only on the use of some straws as fermentation material and the amount of raw materials used was inadequate. Only three or four pits are now being used. Thirdly, a feeling of urgency of utilizing the methane energy resource has not been established in the minds of the rural commune and brigade cadre members. Most of the communes and brigades in the mountain regions feel that "there is plenty of fuel in the hills." They have not considered that wanton cutting of firewood would destroy the mountain forest resources. Communes and brigades in the plains feel that "the rice stalk is a good fuel." They do not see that the energy resource utilization rate of burning rice stalks is less than half of that of using methane. In addition, the phenomenon of diverting special funds for methane construction to other uses has appeared in many counties and communes.

We believe that to effectively promote methane utilization in the rural areas of Guangzhou we must first make sure of "seeking truth from facts and having our feet solidly planted on the ground." Three conditions must exist in the development of methane in the rural areas. There must be a need by the masses. There must be enough resources (each household with more than four hogs on hand). There must be a definite economic foundation (each peasant household capable of spending about 100 yuan of funds for pit construction). In the selection of locations for methane development, we must consider these practical conditions and use measures suitable to local conditions, so that the masses will "receive goods that they can use." When propagandizing and launching the masses for methane development, we should not repeat the method of rushing headlong into mass action. We must engage in promotional work on a locational basis with our feet firmly planted on the ground and develop one location at a time, so that the masses will see the benefits of utilizing methane through actual practice. This is much better than blindly playing with numbers. The energy resources in the rural areas of our municipality are relatively short. The various leadership departments in the rural areas must first understand this reality and establish the feeling of urgency of developing the methane energy resource. They must treat methane development as part of the basic farm construction. Special funds diverted from methane construction must be returned to their original purpose, the supply of raw materials and accessories for pit construction must be solved, and the peasant households and communes and brigades must be supported in their methane development work. Only in this manner can the utilization of the methane energy resource in the rural areas be developed on a firm basis.

SUPPLEMENTAL ENERGY SOURCES

OUTLOOK FOR SOLAR DRIERS ASSESSED

Chongqing XIN NENG YUAN [NEW ENERGY SOURCES] in Chinese, Vol 4, No 2, 5 Feb 82
pp 1-8

[Article by Li Zongnan [2621 1350 2809] and Liu Senyuan [0491 2773 0337] of
the Guangzhou Energy Institute of the Chinese Academy of Sciences: "Situation
and Outlook for Solar Driers in Our Nation"]

[Text] I. Foreword

Since the 1970s, the world's nations have emphasized the energy problem. Developed nations as well as developing nations are all studying and utilizing solar energy to dry agricultural sideline products. At present, many solar drying facilities have been built and the heat gathering surface area has reached over 2,000 square meters.

In our nation, since 1975, several dozen units have developed research in the utilization of solar drying and have built several dozen experimental facilities used for drying in agriculture and industry (See Table 1). Welcomed results have been preliminarily obtained and experience has been accumulated. This has laid a foundation in our nation for future development of research in the utilization of solar energy for drying.

Experiments show that there are many advantages to the utilization of solar energy for drying: (1) It conserves fuel. Ordinarily, drying one ton of materials consumes more than 1 ton of coal. If drying 1 ton of red dates consumes 1 ton of coal, then, drying tobacco consumes 2.5 tons. If solar energy is used for drying, then a large amount of fuel can be conserved for the state, and the cost of drying can be lowered. (2) Compared to natural exposure for drying, solar driers can increase the drying temperature and hasten evaporation of moisture and greatly shorten the drying time. The comparative figures for certain products are listed in Table 2. (3) Solar drying is clean and sanitary. Loss of materials due to rotting, mildew and pollution are reduced, and it also has an insecticidal and bactericidal effect. This improves the quality of products and also prolongs the storage period.

Table 1 Some Solar Driers of Various Localities in Our Nation

Locality	Year built	Type of dryer	Area of heat collector (m ²)	Area of greenhouse (m ²)	Dried substances	Output (jin/period or jin/day)
8th Team, Jishanyaocun, Shanxi	1977	Greenhouse type		54	Red dates, etc.	6,000 jin/2 days
Yanjiangliangdian, Wanrong County, Shanxi	1978	Greenhouse type		80	Granary drying	
Yitong County, Jilin	1979	Heat collector	100		Corn	30,000 jin/4 days
Qingyundian, Daxing Cty, Beijing	1979	Heat collector	74	100	Wheat	16,000 jin/day
Xingtai, Hebei	1979	Light focusing type	90		Food grains	200,000 to 250,000 jin/day
Yantai, Shandong	1979	Heat collector	60		Food grains	
First Cotton Textile Mill, Shanghai	1979	Heat collector	12		Warehouse drying	
Xinjian Cty, Jiangxi	1979	Heat collector	23		Agricultural sideline products	
Wenchang, Hainan, Guangdong	1979	Heat collector	8		Granular rubber	80 jin/3-4 days
Lingjiao, Hainan, Guangdong	1979	Heat collector	16		Sheet rubber	
10th Team, Yaocun, Jishan Cty, Shanxi	1980	Greenhouse type		120	Red dates, etc.	
Datong Cty, Shanxi	1980	Greenhouse type		30	Day lily	
Quwo County, Shanxi	1980	Light focusing type	66		Food grains	
Dayangongluliangdian, Linyi, Shanxi	1980	Light focusing type	10		Food grains	
Feixi Wood Works, Anhui	1980	Heat collector	64		Timber	4 cubic/meters/day
Changge Cty, Henan	1980	Heat collector	50		Tobacco, etc.	1,000 jin/4 days
Changan Deer Farm, Xian	1981	Heat collector			Pilose antler	
Dongwan, Guangdong	1981	Heat collector-greenhouse type	31	27	Fruits	2,800 jin/6 days
Shunde, Guangdong	1981	" " "	13.5	4.5	Silkworm cocoon	Gross weight 500 jin/day
Food Grains Admin Sta, Baoshangcun, Shanghai	1981	Heat collector	36		Noodles	
Food Grains Bur, Shangshui Cty, Henan	1981	Light focus. type	32		Food grains	12,000 - 16,000 jin/day

Table 2 Comparison of the speed of solar heat drying and natural drying

<u>Material</u>	<u>Drying time (day)</u>		<u>Comparative values of the time required for natural drying and solar drying</u>
	<u>Solar drying</u>	<u>Natural drying</u>	
Longan	6	15-20	≥ 2.5
Red dates	17	45-60	≥ 2.6
Timber	5	30-40	≥ 6
Concrete	3	6-7	≥ 2

II. Research and Application of Solar Drying

The types of solar driers tested at various localities in our nation can generally be divided into four types: The first is the greenhouse type. The second is the heat collecting type. The third is the drier that combines a heat collector and a greenhouse. The fourth is the tubular drier that consists of a cylindrical parabola for focusing light. Some representative driers are discussed in the following to separately describe their structure, characteristics, uses and drying effect.

(1) Greenhouse drier: Shangxi, Beijing, Kunming, Guangdong have tested this type of solar driers. Up to the present, Shanxi province has already built 7 greenhouse solar drying facilities with a light gathering surface of more than 600 square meters. Beijing and Kunming have already built concrete storage kilns which are production models of greenhouse driers of a preliminary scale.

The structure of this type of drier is similar to that of greenhouses used to cultivate plants. Its characteristic is that the heat gathering part and the drying chamber are joined together. Figure 1 illustrates a solar drier for red dates in Jishan County, Shanxi province. On the north is a temperature preservation wall. The interior wall is painted black. The south and the east and west sides are temperature preservation walls or transparent glass. The glass roof of the greenhouse slants towards the south. Its slope is equivalent to the geographical latitude. The glass is supported by angle steel or wooden blocks and sealed with grease. An exhaust chimney is on top of the greenhouse near the north wall. Below the south wall is an air intake duct. During operation, a ventilation door is adjusted to regulate temperature and humidity inside the greenhouse. The materials to be dried are placed in plates. When the sun shines through the glass of the greenhouse, it is directly absorbed by the materials and the inner wall of the greenhouse. The temperature in the greenhouse rises. In summer, this can reach 50 to 60°C. This is 20 to 30°C higher than the temperature of the surroundings. In winter, the temperature rises 10 to 20°C, but varies according to meteorological conditions. This type of drying chamber that directly absorbs sunlight is suitable for drying red dates, day lily, pepper, peanuts and cotton and many types of agricultural products that can be directly exposed under sunlight for drying.

In addition, a drying chamber that dries materials half by direct sunshine and half by natural circulation has been built in Jishan County in Shanxi province. An auxiliary drying chamber is built in the back (north side) of the drying chamber that directly absorbs sunshine, as shown in Figure 2. The sun shines on the materials placed at the south end of the greenhouse. The damp and hot air thus heated is partially released via the exhaust at the top while some of hot air flows into the auxiliary chamber on the north side. Then, the air flows from the bottom part of the auxiliary drying chamber back to the transparent greenhouse to be heated again. The auxiliary drying chamber can be used to dry those materials which cannot be directly exposed under the sun for drying.

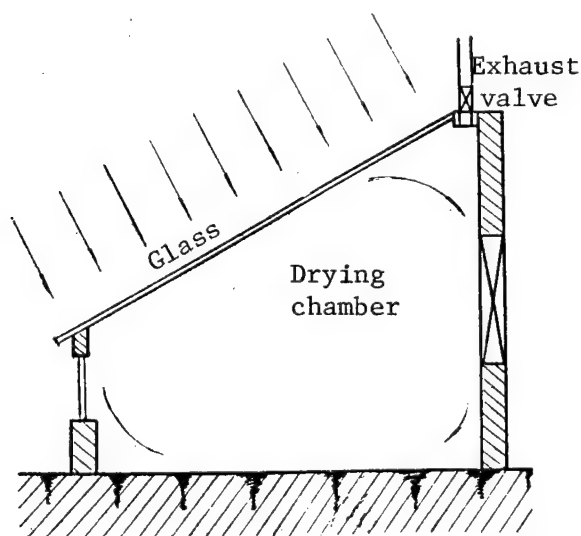


Figure 1

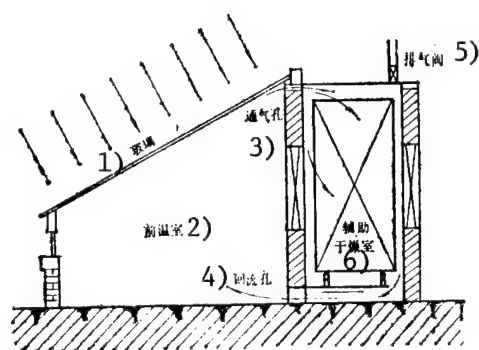


Figure 2 Illustration of the greenhouse type drying chamber with an auxiliary drying chamber attached

1. Glass
2. Front heating chamber
3. Air vent
4. Return air vent
5. Exhaust valve
6. Auxiliary drying chamber

Jishan and Datong in Shanxi province began conducting tests to dry red dates, day lily, pepper and cotton and such agricultural products in 1977. They successfully dried these agricultural products to a safe storage humidity. The products dried quickly. The quality of the products was good. Loss due to spoilage was less, and income increased. For example, the 8th Production Team of Yaocun in Jishan County has a 54 square meter greenhouse type drying chamber used for drying red dates. Materials totaling 1,600 jin are placed in the chamber. During the morning, the green house is closed for drying the materials. At noon and during the afternoon, the green house doors and vents are opened for intermittent ventilation. At night, some of the exhaust valves are shut. On clear days, the materials can be dried after two days. Then, the materials are let to cool for 15 days. This will reduce the water content of red dates to the safe storage moisture content (about 40 percent). Using traditional natural cooling and drying requires 45 to 60 days. Many years of experiment showed that solar drying of red dates reduced the percentage of

spoilage from the 10 to 20 percent of the natural cooling and drying method down to 2 to 3 percent. The red dates were full and their color was bright red. They tasted well and the grade of the naturally ripened dates was improved (See Table 3).

Table 3 Comparison of the quality of red dates dried by the sun in drying chambers, dried over fire and naturally cooled and dried

<u>Drying method</u>	<u>Percentage of spoilage</u>	<u>Shape</u>	<u>Color</u>	<u>Taste</u>
Sun dried	2-3	full	Bright red	Sweet
Dried over fire	2-3	Wrinkled	Dark red	Slightly burnt
Naturally cooled and dried	10-20	Shrunk	Red	

Datong County utilized the solar energy greenhouse to dry day lily, overcame damage caused by wind and sand and dust (The content of dust in day lily dried naturally in this region is high). The products were clean and fresh, and they were welcomed by foreign trade departments.

(II) Heat collecting type drying facility: This type of drying system has a separate heat collector and a drying chamber. The Xian pilose antler drier and the Hainan rubber drier are such driers. For continuous drying of the materials, a stove can also be added to this drying system. For example, the solar energy tobacco drying facility in Changge County, Henan province has a coal burning stove. The drier for bean curd strips at the Huangxi Cultivation Farm in Xinjian County in Jiangxi province has a marsh gas burning chamber. The timber drying kiln at the Feixi Wood Works not only has a timber burner, it also has a heat storage facility. On clear days, the solar atmospheric heat collector is used to provide heat. At night or on overcast days, the heat storage facility or ordinary fuel fired burners are used to provide heat.

The solar timber drying kiln of the Feixi Wood Works is described in the following as an example. This facility consists of a solar atmospheric heat collector, a drying chamber, a pebble heat storage chamber, a wood scrap stove, a smoke-air heat exchanger and an air circulating ventilator. After the drying kiln was built, 8 drying experiments were conducted. The period for drying pine was 5 days. The moisture content dropped from 30 to 14 percent. Hard wood which was difficult to dry required about one week. During the day, drying required the use of the ventilator. The atmospheric heat collector was used to provide heat to the drying chamber and the rock heat storage chamber. At night, the heat storage device or the wood scrap burner was used to provide heat. It was shut down at midnight to let the drying chamber retain a definite humidity. The timber was enclosed in the kiln to allow the moisture inside to disperse and to reduce the temperature gradient inside the timber. The temperature inside the kiln was 20°C higher than the surrounding atmospheric

temperature. The relative humidity was 45 percent. When the humidity surpasses 60 percent, the air was ventilated to reduce humidity. Experimental results showed that when the solar drier was used to dry timber, the quality of the timber was better. Except for individual logs which cracked slightly, other shortcomings were not discovered.

The heat collecting type drier has been used at various places in our nation in experiments to dry grains, tobacco, noodles, rubber, Chinese herbs and for warehouse drying.

Yitong County in Jilin province, Daxing County in Beijing City, Yantai in Shandong province used the atmospheric heat collector to heat air and the hot air was channeled into silos to dry corn and wheat and such grains. The drier at Yitong County has a heat gathering surface of 100 square meters. The inner diameter of the silo was 6 meters. The average water content in corn dropped 10 percent and daily output of corn was 5 tons. The heat collector of the wheat drier in Daxing County in Beijing City uses a flat box to produce hot water and hot air.

Ordinarily, it is used to provide hot water. In summer, during wheat harvesting time, it is also used to dry wheat. At this time, the box is filled with non-circulating water to store heat. Air is heated only when it flows across the heat absorption plate. Together with the air heated by the greenhouse next to the facility, the hot air is drawn by the ventilator into the cylindrical silo to dry wheat. The area of the heat collector of the facility is 74 square meters. The areas of the greenhouse is 100 square meters. Air flows at about 6,000 cubic meters/hour. During cloudy days, the temperature of the hot wind is 37° to 47°C, higher than the temperature of the surroundings by 8 to 13°C. After drying for 5 hours, the moisture content of 16,000 jin of wheat dropped from 30 percent to 24.5 percent. On clear days, the temperature of hot air rises 7 to 22.5°C. Each day, the moisture content of 16,000 jin of wheat can be reduced from 20 percent to 4 percent.

Changge County in Henan province conducted experiments in using solar energy to cure tobacco and to dry noodles. The period of curing tobacco by solar energy is 4 days. During the course of curing, the temperature and humidity at each stage are strictly controlled: During the yellowing period, the temperature is controlled between 38 and 45°C and during the color fixing period, the temperature is controlled between 45 and 55°C. During these two periods, the relative humidity is between 75 and 80 percent. During the drying period, the temperature is between 55 and 75°C and relative humidity is between 30 and 40 percent. The heat collecting surface of the device is 50 square meters. There is an auxiliary coal stove for heating. The facility can take 1,000 jin of fresh leaves, and it can conserve 120 jin of coal. This is 25 to 30 percent less than the amount of coal previously required in drying tobacco in pits. The quality of the flue-cured tobacco improves and the selling price is 0.1 yuan/jin more than the cost of curing tobacco in fired pits or piling in pits. To improve the rate of utilization of the solar curing room for tobacco, the room is used for drying noodles and cultivating mushrooms during ordinary times. The room can dry 1,200 to 1,500 jin of noodles each time. The drying temperature is 30 to 40°C. From March of this year to the beginning

of May, the facility has already produced 30,000 jin of noodles. It is estimated that the annual output would be 100,000 to 150,000 jin. Noodles dried in the solar energy facility are white. After evaluation, the quality of the noodles was shown to be visibly higher than the quality of noodles in ordinary production in the county.

The Changan Deer Farm in Xian City uses the atmospheric heat collector in place of the coal fired furnace to dry pilose antler (the maximum drying temperature for red deer antler is 80°C, that for sika deer antler is 60°C). Drying continues for 17 hours. After drying, 1.3 jin of fresh antler shrink to 0.8 jin. The color is good, there is no foul smell, drying is even, and satisfactory results have been obtained.

Hainan Island of Guangdong province has built two small experimental solar rubber drying facilities. The heat gathering surfaces are 16 square meters and 8 square meters respectively. They were used in experiments to dry rubber pieces and granular rubber. The drying period was 3 to 4 days. The quality of rubber dried in the solar drier was better than the quality of flue-cured rubber dried by the traditional method in the flue-curing chamber. The content of volatile substances, plasticity retention, initial value of plasticity, and physical indices related to the drying technique all reached or surpassed the criteria of first grade standard rubber.

(III) Heat collector-greenhouse type drying facility: This is a drying facility combining a heat collector and a greenhouse. As illustrated in Figure 3, its drying chamber is a greenhouse with a transparent roof. The materials to be dried are placed in pans inside the greenhouse. During the day, the materials to be dried directly absorb solar radiation through the glass roof and are permeated by the hot wind from the atmospheric heat collector, thus they absorb the heat in the greenhouse and the heat of the heat collector. The drying temperature in the greenhouse rises correspondingly. According to preliminary experiments conducted by the Guangzhou Energy Institute, when the area of the greenhouse and the surface of the heat collector are related 1:1, the drying temperature can be increased 5 to 10°C (depending on meteorological conditions).

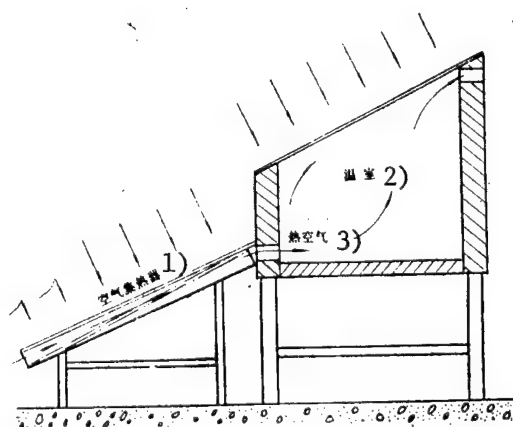


Figure 3 Illustration of the heat collector-greenhouse type drier

Key:

1. Atmospheric heat collector
2. Greenhouse
3. Hot air

Dongwan County and Shunde County in Guangdong province separately built this type of drying facilities. The former used the facility to dry longan and litchi while the latter used the facility to dry silkworm cocoons. The fruit drying system in Dongwan is a tunnel shaped solar drier. The heat collector and the light gathering surface of the green house are 31 square meters and 27 square meters respectively, and the facility also has a coal stove as an auxiliary heat source. Fruits to be dried are transported by small carts into the tunnel kiln of the green house. The capacity of the kiln is about 2,800 jin. The ventilator is used to force hot wind to permeate the layers of the materials. When the air flow reaches 800 cubic meters/hour, the temperature in the greenhouse on clear days can reach 50 to 70 C. The fruits are removed from the kiln after 6 days of drying. The solar energy silkworm cocoon drying facility at the Xinfu Brigade of Leliu Commune in Shunde County has a heat collector with a heat gathering area of 13.5 square meters. The area of the greenhouse is 4.5 square meters. On clear days, the indoor temperature can reach 60 to 80°C. Twenty-nine plates of cocoons (gross weight of about 250 jin) can be dried together. After drying for 2 to 3 hours, the temperature will be high enough to kill the silkworm larvae and dehydrate the cocoons.

(IV) Light focusing type drying facilities: Xingtai in Hebei province, Quwo County in Shanxi province and Shangshui County in Henan province have test manufactured the light focusing type food grains drier. The drier consists mainly of a cylindrical parabolic mirror, a tubular absorber, a slow cooler, a lift to transport materials, and a tracking system. Of these driers, the one at Xingtai in Hebei is the largest. It has three sets of light focusing mirrors totaling 90 square meters. The thermal efficiency is about 40 percent. The temperature of the absorber is 80 to 120°C. The materials to be dried are lifted by the lift into the tubular absorber. The mechanism operates continuously. Grains are fed from one end and exit from the other end. The moisture content drops 1.5 to 2.0 percent and the insecticidal efficiency is over 95 percent. Between 20 and 25 tons can be processed daily. The structure of this type of driers is complicated, and manufacturing cost is high, but such driers consume only one half the amount of electricity required by a fired roller type food grain drier and uses 97 percent less electricity than a high frequency medium food grains drier.

Yet, whether the light focusing type drier is suitable for drying grains is worth considering. This is because in general, the temperature required for drying grains is relatively low, and drying grains does not require a high temperature and quick drying system that has a high manufacturing cost. According to reports, in India and Burma, the light focusing type drier is used to concentrate coconut juice. In the Soviet Union, it is used to radiate rice grains and cotton seeds to increase the yield of rice grains by 20 to 25 percent. The driers used for drying grains are almost all cheap heat collecting type drying systems.

III. Analysis of the Utilization of Solar Heat for Drying

Progress in the study and popularization of using solar energy to dry industrial and agricultural products in our nation has been slow compared to the use of solar water heaters. But its development has been fast in recent years and good economic results have been realized. Compared to other ways of

utilizing solar energy, such as the solar water heater, the solar stove, solar air conditioning for refrigeration, and solar houses, solar drying serves industrial and agricultural production much more and more directly if the above are used more for living. Many agricultural sideline products and industrial products have to be dried. Most are dried by convection drying. This involves the use of hot air (or smoke) to dry and process products that satisfy certain specifications. This process is very favorable to utilizing solar energy.

In using solar energy to dry damp materials, a low temperature drying system is more suitable than a high temperature drying system. For example, if the environmental temperature is at 27°C, the radiation loss when the heat absorbing plate of the atmospheric heat collector is heated to 90°C is 2.2 times that when the heat absorbing plate is heated to 60°C. It is 3.5 times when the heat absorbing plate is heated to 50°C. As the temperature of the heated air rises, the loss of heat radiation increases exponentially.

At present, most of the domestic solar drying facilities are low temperature driers. The greenhouse type drying facility is simple in structure, it is easily built, management is convenient, investment is much less, and the gain is visible. For example, the greenhouse type solar drying chamber of the 8th Production Team of Yaocun in Jishan County, Shanxi province, can dry 6,000 jin of red dates every two days and it can also be used to dry wheat, corn, pepper and noodles. During the three years from 1977 to 1979, it dried a total of 62,000 jin. Because spoilage of the red dates was reduced, the grade of naturally ripened dates was improved, and the increase in revenue reached 3,000 yuan while the investment in the facility was only 2,400 yuan.

The Shanghai First National Cotton Mill has a heating room in almost every shop to reduce the relative humidity in the warehouse for spare parts of textile machinery and to prevent the spare parts of the machinery from rust during storage. The whole plant has a total of 12 heating rooms. Originally, these heating rooms all used infrared light bulbs for heating. They used 90,000 kilowatt-hours of electricity a year. The temperature required in these heating rooms was about 40°C. To conserve electricity, they built 12.2-square meter atmospheric heat collectors by themselves using waste materials of the plant. The heat collectors were installed in front of four heating rooms and the original heating rooms that used only electricity were changed to using solar energy on sunny days and electricity on overcast days. Each year, about 20,000 kilowatt-hours of electricity were conserved and the investment was small. For example, the cost of materials for the 2.8-square meter atmospheric heat collector for the steel mesh heating room of the north textile shop of the plant was only 85 yuan.

The intake air temperature of the solar timber drying kiln is to to 30°C higher than the environmental temperature. It is also a low temperature drying system. According to the experience of the Feixi Wood Works, the cost of drying each cubic meter of timber is 15.5 yuan (including depreciation and management cost), lower than that of the old fashioned steam drying room (21 to 23 yuan/cubic meter).

The study and utilization of solar energy in our nation is still at the beginning stage. Local practical experience is still not rich enough. Therefore, a series of problems do exist:

(I) Basic research is insufficient: To heat collector type drying system, the atmospheric heat collector is a key part. At present, the study of atmospheric heat collectors is not sufficient and a nationally standardized product still does not exist.

The testing of atmospheric heat collectors to a certain degree is more difficult than testing a fluid heat collector (such as accurately measuring the temperature at the fluid intake and the measurement of air flow). There is still no unified and standard method for organizing experimental data to evaluate the performance of atmospheric heat collectors.

The goal of studying atmospheric heat collectors is to reduce the cost per unit area and thus reduce the manufacturing cost of the entire solar air heating system. Improving the efficiency of atmospheric heat collectors is a method to reduce unit energy cost. But improving efficiency will often increase construction cost of the heat collector. Whether it is worthwhile can be judged from the effective cost factor C, i.e.:

$$C = \frac{\text{Percentage of increase in performance of heat collector}}{\text{Percentage of increase in cost of heat collector}}$$

Using the heat collector in which air flows underneath the heat absorbing plate as a basis for comparison, the larger the value of C the better the total result.

The heat absorbing plate is the core of the atmospheric heat collector. Many units in our nation have been interested in the multiple hole bed. The purpose is to improve heat transfer between the heat absorbing plate and the flowing air and to reduce the loss of heat through the roof of the atmospheric heat collector. Tianjin University, the China Science and Technology University, the Shanghai Machinery Academy utilized 6 to 12 layers of aluminum mesh as the heat absorbing plate. This type of heat absorbing plate has a very small fluid drag, and the product of the coefficient of heat release and the area of heat exchange is very large. These are all favorable conditions for improving heat conduction. But the price of such a heat absorption board is rather expensive and the manufacturing cost is 50 to 60 yuan/square meter. The Guangzhou Energy Institute of the Chinese Academy of Sciences transplanted the wing blades of the winged heat exchanger used in air separation equipment onto the solar atmospheric heat collector. The results of preliminary exploration to improve heat conduction of the heat absorption board were not bad. The cost of such aluminum blades is relatively low, only 14 yuan/square meter. The results of analysis of comparing the various heat absorbing surfaces showed that the cost efficiency factor C of mesh materials is not high. Therefore, some scholars favor the use of heat absorbing boards of other expanded surfaces.

It should be pointed out that foreign nations already have a history of 20 years of research in heat absorbing boards using pulled materials. But, today, such materials still cannot replace all other forms of heat absorbing boards. Therefore, we should combine our efforts with the situation in our nation to develop low cost and highly efficient atmospheric heat collectors from many angles.

Basic research in the greenhouse type and the heat collector-greenhouse type solar drying systems is also insufficient. Especially in the latter, the area of the light gathering surface of the heat collector as a proportion of the greenhouse has a definite relationship with the temperature inside the greenhouse. When the proportion is not appropriate, the light gathering surface in the greenhouse cannot serve to gather energy but will increase heat loss. Such research and analysis are still scarce.

(II) Drying facilities have not been fully utilized: Solar drying facilities used for processing agricultural sideline products must include consideration of the problem of comprehensive utilization. They should not be used only for drying one type of crop, otherwise their rate of utilization will be low, and the cost of solar drying of such products will increase. Agricultural production is strongly seasonal. Maturation and processing of one type of agricultural crop take up only a very short period in a year. For example, the wheat drying facilities are only used for one month out of a year. Solar drying facilities for fruits are the same. The seasonal nature is also very strong and they are used only for a short period. Thus, if one facility cannot be used for drying many types of crops, then it will not serve its function fully.

The solar wheat drying facility at Wingyundian in Daxing County in Beijing City is a heat collector that combines heating of air and heating of water and its advantage is that it serves two purposes. But the structure of this type of heat collector, whether used singly as an air heater or singly as a water heater is not as rational as that of the simple atmospheric heat collector or the water heater.

(III) Manufacturing technology is poor: At present, many solar drying facilities in our nation have a common fault. The manufacturing technology of the heat collector, pipes and valves is not good. Leakage is serious. Experimental data are inaccurate and operating efficiency is affected. There are two reasons: 1. There are no special factories producing them. Most efforts are first tries and there is no experience. 2. Efforts have been hasty and there are no detailed consideration and strict inspection in the design and in construction.

(IV) When popularizing the application of solar drying facilities, a mistaken idea of not emphasizing energy conservation exists: The Shanghai First National Cotton Mill rebuilt its heating rooms and utilized solar energy to save electricity with visible results. The Shanghai City Textile Bureau held an on-site meeting in 1980 but for a year, the experience was not popularized and applied. It was mainly because some people believed that a cotton textile mill uses several million kilowatt-hours of electricity a year and conserving several dozen thousand kilowatt-hours of electricity is but a "small number" and this did not attract sufficient attention. This is also related to the insufficient amount of propaganda to popularize the use of solar energy.

IV. The Outlook for Solar Drying

Whether solar drying can be popularized is determined by the fuel supply situation of the locality, the cost of obtaining solar energy and the degree of maturity of solar drying technology.

Our nation is expansive. Solar energy resources are rich while fuel in the farm villages is deficient and there is also a great shortage of energy sources in cities. If a solar drying system that is economical and effective can be developed, it is not hard for people to accept it. Many problems that need to be solved further in the study and utilization of solar drying technology at present are presented below:

(I) We should further analyze and study at which places and under what conditions and what types of materials can be dried by using solar energy to realize satisfactory results: Facts show that not all materials dried by solar energy have the same result. For each material, there is a traditional technique of drying. Some specialty agricultural products have more stringent requirements. Because solar energy is unstable, we must consider whether it suits the requirement of the product. Therefore, during this initial stage of popularizing and utilizing solar drying, we should first use it for products that do not have a strict demand on the technique of drying. And we should gradually explore the best solar drying technique for various materials.

(II) To reduce cost of drying, solar drying systems should be operated throughout the year and comprehensively utilized: What we call comprehensive utilization has two meanings: 1. The drying system is not only used for drying one type of material, there are seasonal changes, and it should adapt to the demands for drying many types of materials so that there will be materials for drying throughout the year. 2. The amount of heat gathered by the solar heat collector is not only used for drying, it should be used for other applications, such as heating houses, heating water, etc.

(III) We should develop highly efficient and low cost atmospheric heat collectors and establish the criteria and methods for testing atmospheric heat collectors: There are many models of heat absorption boards for the atmospheric heat collector. They should be combined with our nation's actual situation. Local materials should be used and tested to select the best design to develop highly efficient and low cost atmospheric heat collectors.

One of the key methods to reduce the cost of solar driers is to reduce the cost of the atmospheric heat collector. Low priced materials should be widely utilized. We should start out by reducing the cost of solar driers and it is not necessary to exert all efforts to pursue high efficiency in heat collectors. We should judge on the basis of the cost of obtaining a unit of energy (for example, 1 million kilocalories).

To promote research in atmospheric heat collectors and to facilitate comparison and evaluation of the performance of the various types of atmospheric heat collectors, we must unify the diversified testing methods in our nation at present, and we should quickly establish a standard method of testing atmospheric heat collectors on the basis of summarizing research and experience.

(IV) We should develop small and varied solar driers:

Many localities in our nation's farm villages have implemented the management system of contracting production to families. Products that originally were treated centrally by the production teams are now dispersed to the families. Therefore, the solar drying facilities built for the production teams as the users cannot fully develop their function. To adapt to this situation, we should develop small and varied types of simple solar driers which can be easily built by the masses. Whole-body driers can be manufactured, i.e., the heat collecting portion and the container for the substances to be dried can be built as one unit to reduce cost and to more effectively utilize heat energy.

(V) We should pay attention to storing energy: Application of energy storage has special meaning in solar drying systems. If we regard the water heater itself as a heat retainer, then the atmospheric heat collector cannot serve to store heat. The specific heat of air is small while the volume per unit weight is large. Air flowing in a drying system continues to absorb heat and continues to disperse heat.

According to the characteristics of drying materials, there are generally three stages, a preheating stage, an equal speed drying stage and a reducing speed drying stage. In different stages, the amount of moisture that evaporates is different and the amount of heat required is different. In the preheating and reduced speed heating stages which require less heat, a large amount of hot air is released and the heat collector cannot fully develop its function but the equal speed drying stage requires a large heat supply. A heat storage can improve the heat utilization rate of the whole system. This means, when not much heat is being used, heat is stored for use when a large amount of heat is required or the heat supply period can be prolonged so that the drier can continue to operate at night.

(VI) Solar energy should be used in combination with ordinary energy resources or other new energy sources: Solar energy is greatly affected by climate and day and night. The energy radiated upon earth is not constant. Therefore, it is difficult to use solar energy for continuous drying of materials and for materials that require high temperature quick drying. On the one hand, an intermittent supply of heat to dry foods that easily spoil and rot (fruits, bean curd strips, noodles) will frequently cause great loss. On the other hand, in drying rubber, the last drying stage requires that the temperature be raised to 120 C. It is very difficult to reach this temperature when using a flat board solar atmospheric heat collector. The investment in other types of solar energy facility is large. To solve this conflict, a method that combines the use of solar energy-marsh gas or solar energy-ordinary energy source is better. The solar drying system of Xinjian County in Jiangxi Province, the Feixi Wood Works in Anhui province and Dongwan County in Guangdong Province all have a burning chamber to supplement the insufficiency of solar energy. In this type of a system, attention must be paid to matching the various parts properly to make the flow process rational and to make adjustments easy.

9296

CSO: 4013/36

SUPPLEMENTAL ENERGY SOURCES

'RENMIN RIBAO' ON DEVELOPING FUEL FORESTS

HK240919 Beijing RENMIN RIBAO in Chinese 17 Apr 82 p 2

[Commentator's article: "Firewood-Deficient Areas Should Make Greater Efforts to Develop Fuel Forests"]

[Text] There are seven daily necessities: firewood, rice, edible oil, salt, sauce, vinegar and tea. Firewood has always been an important means of people's livelihood since ancient times. At present, there are serious fuel shortages in our rural areas: About half of China's peasant households are short of firewood for over 3 months of the year. These peasants are busy finding firewood all year round; nevertheless, they still find the firewood problem difficult to solve now and then. Due to firewood shortages, forests, shrubs and even turf in many areas have been felled and sabotaged, thus aggravating soil erosion; stalks of crops cannot be put back into the fields, thus bringing about a decline in soil fertility. Fuel shortages in our rural areas have become serious obstacles to quickening the pace of developing agriculture.

The "Decision on certain questions regarding forest protection and forestry development" issued by the CCP Central Committee and the State Council in March last year noted: "Firewood-deficient areas must regard the development of fuel forests as their most important afforestation task." There are many fast-growing and fast-sprouting fuel tree seeds in both the northern and southern parts of China. For example, Northeast China has poplar, willow, birch and oak; Northwest China has sandy willow (sha liu 3097 2692], buckthorn, narrow-leaved oleaster, (ning tiao) [2899 2742], (suan ci) [6808 0459], and saksaul [suosuo 2747 2747]; North China and the central plains have locust, false indigo, Chinese tamarisk and poplar; and South China has pine, oak, eucalyptus, acacia, (li suo shu) [7812 4792 2885], beefwood and silk trees. Three to 5 years after being planted, these trees will be of benefit to the people. An individual's yearly needs for firewood can be met by 1 to 2 mu of fuel forests. At present, some areas have solved their fuel shortage problems by planting fuel forests. Wendeng County in Shandong Province was beset with firewood difficulties in the past. After promoting afforestation and closing hillsides to facilitate afforestation, the county can now solve more than 3 months' firewood shortage problems. Saline-alkali soil can be found everywhere in Xianfeng commune, Hotan County, Xinjiang. During a rainy season a few years ago, members of the commune planted (ning tiao) [2899 2742] and

(suan ci) [6808 0459]. As a result, the commune became self-sufficient in firewood 3 years after the planting. Ejin Horo Banner, Ih Ju League, Nei Monggol, which is located on the northern fringe of the Maowusu Desert used animal excrement as fuel in the past. The banner has planted a large number of sandy willow [sha liu 3097 2692] over the past few years. Sandy willow can be gathered 3 years after planting and can also bring about a large yield of firewood. Fuel forests can be easily built at a low cost and can also produce the desired result quickly. Generally speaking, all fuel tree seeds have the capability of natural regeneration and all fuel trees will sprout new buds after being felled. If fuel trees are properly managed and used, they can yield firewood for many years.

Just like other forests, fuel forests as green vegetation have various beneficial qualities such as keeping off the wind, sand fixation, water and soil conservation, protecting farmland and grassland, and improving ecological balance. The leaves of locust, false indigo, narrow-leaved oleaster and (ning tiao) [2899 2742] are very nutritious feed and are also green manure with a very high nitrogen content. With the existence of more firewood, we can have more waterlogged stalks to be used for producing marsh gas. Such waterlogged stalks can also be directly put back into the fields to increase the sources of organic matter for cultivated areas. These conditions show that the building of fuel forests is also an important measure in promoting the development of agriculture and animal husbandry.

In developing fuel forests, we must implement the policy of "allowing people to own forests they plant" and give full play to the enthusiasm of communes, brigades and commune members. Fuel forests can be collectively built, can be managed under unified leadership and can be distributed to every household. Collectively built fuel forests can also be distributed to every household for separate management and use. According to policy regulations, areas where the conditions exist should allow every household for separate management and use. According to policy regulations, areas where the conditions exist should allow every household of commune members to have up to about a dozen mu of private hilly area, sandy beach or desert for planting trees and building grassland, so as to solve firewood shortage problems and to meet the needs for commercial forests. This policy must be gradually implemented. At the same time, we must also strengthen technical guidance for developing forest development. We must take such measures as are suitable to local conditions and select fast-growing and high-yield tree seeds that have a high degree of calorific capacity, combine arbor with shrub and grass, combine fuel forests with commercial forests and shelter-forests, do well in closing hillsides to facilitate afforestation, pay attention to having a rational gathering of firewood and improve our fuel forests' capability of natural regeneration. "As long as the green mountains are there, one need not worry about firewood." During the all-people voluntary afforestation movement, firewood-deficient areas must plant more fuel forests in a planned way so that their green mountains can always be there and so that they can always make use of firewood.

CSO: 4013/88

SUPPLEMENTAL ENERGY SOURCES

REN ZHONGYI INSPECTS METHANE PRODUCTION PITS

HK200655 Guangzhou Guangdong Provincial Service in Mandarin 2350 GMT 19 May 82

[Summary] "Yesterday afternoon provincial and municipal responsible leaders Ren Zhongyi, Liang Lingguang, Xu Shijie and Ou Chu went to Koukou No. 1 production team of the Hedong people's commune in the suburbs of Guangzhou to inspect methane production."

They went to the homes of commune members to inspect the utilization of low pressure household methane collection pits. They also listened to a report by the secretary of the Hedong Commune CCP Committee on the popularization of low pressure household methane collection pits in the commune.

"Comrade Ren Zhongyi held that because Guangdong lacks energy resources, the development of low pressure household methane collection pits is an orientation and an important undertaking. He pointed out that it is necessary to conscientiously popularize the successful experience of the Koukou No. 1 production team in developing methane so that family-produced methane becomes a common practice. Comrade Ren Zhongyi also suggested the establishment of a methane technical service center in the suburbs of Guangzhou to speed up the pace of methane production in the suburbs."

CSO: 4013/88

SUPPLEMENTAL ENERGY SOURCES

BRIEFS

ANHUI METHANE PROMOTION--The Anhui Provincial People's Government held a representative meeting of advanced collectives and individuals in promoting the use of marsh gas on 28-31 March in Hefei, to sum up experience, commend the advanced, draw up plans and set tasks for development of marsh gas use in the province. Responsible persons of the Provincial CCP Committee and People's Government, Zhou Zijian, Li Shinong, Wang Guangyu, Meng Jiaqin and Meng Fulin, attended the meeting. According to incomplete statistics, more than 7,000 marsh-gas-generating pits were built in the province in 1981, bringing the total number of pits in the province to nearly 40,000. [Hefei Anhui Provincial Service in Mandarin 1100 GMT 6 Apr 82 OW]

CSO: 4013/88

CONSERVATION

OFFICIAL URGES USE OF OFF-PEAK ELECTRICITY FOR RESIDENTIAL PURPOSES

Beijing ZONGGUO CAIMAO BAO in Chinese 6 Feb 82 p 3

[Article by Mao Tieqiao [3029 6993 2890], member of the National PPCC and former deputy director of the Guizhou Office of Communications: "A Proposal To Save Energy Resources, Enrich the Country and Benefit the People"]

[Text] Guizhou's coal and waterpower resources are abundant: the province ranks third nationally in proven coal deposits and sixth nationally in waterpower resources which can be used to generate electricity. The supply of hydroelectric power is also plentiful now. We should consider developing this energy source to maintain the people's standard of living. First of all, as quickly as possible we should supply Guiyang's excess electric heat to people for cooking and other domestic purposes. I refer here to periods of low electric load for electricity supplied to factories, i.e., electricity from 5 am to 8 am, from 12 noon to 2 pm and from 6 pm to 8 pm. (During these periods the electric circuits are turned off. When residents need electricity they plug into the lighting circuit.) The electricity which residents use during these times will not have any impact on the electricity the plants use for production now will it require an increase in generators and new construction. Existing equipment can be used for generation, transmission, transforming and distribution and will require only the addition of a special circuit and relevant equipment for off-peak period transmission. Technical forces within Shaanxi are capable of taking care of design, construction, movement and maintenance. The necessary materials can be found domestically and will not require spending foreign exchange to buy them abroad.

The Guiyuan municipal area now has 150,000 households with over 660,000 people. Annual domestic coal usage requires over 270,000 tons, producing over 50,000 tons of cinders. The two combined require over 80,000 trips by trucks capable of carrying 4 tons, at a cost of over 5,000 tons of fuel. If electricity is used in place of coal, the state can save over 4 million yuan a year in shipping and fuel expenses.

If the 4 or 5 yuan which each household now spends every month on coal were spent on electricity instead, the electric power department would increase its income by over 6 million yuan. Because off-peak electricity is used there would be no big increase in generating costs. If residents were to use electric heat it would promote expansion of consumer electric equipment, materials and household appliances industries. It will also be advantageous for

purifying the air, avoiding municipal pollution and saving energy: taking care of many problems with one act.

Building a special circuit for citizen use of electric heating will require an investment of 24 million yuan. Electrical networks can be combined and used for different purposes by staggering time periods. For example, the first period project investment of 9 million yuan could provide electric heat for 200,000 people. Taking into account Guizhou's current straitened financial situation, perhaps the State Council would approve appropriating part of the profit from Guizhou's electrical generating income for use as investment.

Last year, the Guizhou Planning Committee, Economic Committee and Construction Committee conducted a feasibility study of reforming the structure of Guiyang's civil use thermal energy and formulated a proposal and asked relevant departments to make Guiyang a test city for use of electricity for heating. This important proposal for enriching the nation and benefiting the people should be rapidly implemented, positively and seriously.

8226

CSO: 4013/11

CONSERVATION

YUNNAN CONSERVES OVER 120 MILLION KWH OF POWER IN 1981

Kunming YUNNAN RIBAO in Chinese 27 Feb 82 p 2

[Article by Zhang Hungde [1728 3163 1795]: "Strengthen Management of Electricity Use; Promote New Techniques of Electricity Conservation; Yunnan Conserved Over 120 Million Kilowatt-hour of Power in 1981"]

[Text] The industrial and communications enterprises in our province conscientiously strengthened the management of electricity use, promoted new techniques of electricity conservation, increased the utilization rate of energy resources, and achieved notable results in electricity conservation last year. Based on statistics of the 24 systems and regions supplied by the two power networks of Central Yunnan and Southern Yunnan, a total of over 120 million kilowatt-hours of electricity was conserved last year, exceeding the conservation task of 100 million kilowatt-hours assigned by the state by 21 percent.

In strengthening the management of electricity use last year, the various industrial and communications enterprises in the entire province first made sure that various levels of energy resource management organizations were established and improved. They made sure that people were assigned for energy conservation work and that people were there to close any loopholes of waste. The provincial metallurgical, chemical, and coal industries are the three major systems using electricity in our province. These three systems further improved their various levels of management organizations for electricity use, assigning personnel at each level for electricity management either on an exclusive basis or concurrently with other assigned responsibilities, concretely defining energy conservation measures and energy conservation tasks, and thus achieving new developments in energy conservation work. These three systems conserved a total of 51 million kilowatt-hours of electricity last year. In the strengthening of electricity management, many systems and enterprises treated the reduction of unit power consumption as the important link of power conservation and refused to let go of this work. In the assigning of production plans, most of the plants and mines also assigned power consumption targets at the same time. These targets were further divided on a level by level basis and clearly defined by shops, groups, or major machinery units. Conservation was rewarded and waste was penalized. As a result, unit consumption gradually decreased and electrical energy utilization rate was continuously improved. Last year, on the average, each ton of electric furnace steel consumed 250 kilowatt-hours less electricity, each ton of synthetic ammonia consumed 406 kilowatt-hours less electricity, each ton of fertilizer from small chemical

fertilizer plants consumed 156 kilowatt-hours less electricity, and each ton of electrolytic copper consumed 178 kilowatt-hours less electricity. The various units of the provincial power system also reduced their plant consumption and line losses by every means possible. Last year, the entire system conserved a total of more than 33 million kilowatt-hours of electricity.

Many systems and regions also widely promoted and adopted the new experiences and new techniques of high efficiency fans, wu di fa [literally, without bottom valve] water pump operation, reconstruction of electrical resistance furnaces with aluminum silicate material, and electronic power conservation, and as a result conserved energy resources. Last year, 317 water pumps in the province were reconstructed with a total generator capacity of over 17,000 kilowatts and 154 electrical resistance furnaces were reconstructed with a total power of 8,400 kilowatts.

5974

CSO: 4013/68

CONSERVATION

PLANNED USE AND CONSERVATION OF ELECTRICITY

Fuzhou FUJIAN RIBAO in Chinese 25 Mar 82 p 1

[Article: "Provincial Government Sends Out Notification Requiring Planned Use of Electricity and Conservation of Electricity"]

[Text] Based on the current condition that the contradiction between electricity supply and demand is relatively severe, the Provincial Government recently sent out a notification requiring planned use of electricity and conservation of electricity to guarantee the normal progress of production.

The announcement requires various places to stress the following items of work:

1. Strengthen leadership in "three electricity" ["san dian"] work. Strictly enforce electricity consumption quota as transmitted by the province. These quotas cannot be exceeded. Regions which have already exceeded their planned electricity usage should adopt effective measures to rapidly reduce consumption. At the same time, the work of avoiding the peak load and yielding electricity [ran dien] should be properly carried out in order to improve the load efficiency. For those units that do not practice adjusting to peak load and yielding electricity, local electricity control departments should impose electricity consumption restrictions or cut off electricity use.
2. Distribution of electricity consumption quota should be on a selective basis in favor of the good. Agriculture, light and textiles industries, energy resources industries, processing for export, communications, communication and transportation, and people's daily livelihood consumption should be given priority. The supply of electricity should be assured as much as possible to enterprises whose products are of good quality, meet the needs of the market, and have high economic benefits. Less or no electricity should be provided to enterprises whose products are poor in quality, have high consumption, and are already overstocked. For those enterprises with large electricity consumption, some of them should be restricted in their production; for others, arrangements should be made to stop production for examination and repair.
3. Effective electricity conservation measures must be implemented with determination. Conservation tasks should be assigned clearly on a level by level basis. They should be strictly checked and awards or punishment should

be given. The use of electrical heating should be controlled, and electricity for daily living requirements should be further conserved.

4. All power plants (stations) should operate safely and economically and strive to lower fuel consumption and improve quality of power supply. Railway transportation departments must assure the movement of coal use by power plants in order to guarantee the full generation of thermal power.

Provincial Economic Committee

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CSO: 4013/56

CONSERVATION

100,000 TONS OF COAL SAVED BY COMMERCIAL FUEL ORGANIZATIONS

Lanzhou GANSU RIBAO in Chinese 18 Feb 82 p 2

[Article by Xie Shouguo and He Qijun: "100,000 Tons of Coal Saved in 1981 by Commercial Fuel Organizations in Our Province; Notable Results Achieved in Energy Conservation Work by Fuel Organizations in Linxia Zhou"]

[Text] Simultaneously with properly carrying out their coal supply work, the workers in the various levels of coal management departments in our province's commercial fuel organizations also engaged in coal conservation activities last year. They actively implemented a movement to modify furnaces and stoves, organized the rational transportation of "san jiu" ["three-nears"] of near-mine, near-station, and near-plant direct transfer, and carried out "san sao" ["three sweeps"] of sweep cargo locations, sweep cars, and sweep yards coal conservation activities. The total savings were 102,000 tons of coal valued at over 3,110,000 yuan.

Notable results were achieved last year by the fuel organizations of the Linxia Hui Nationality Autonomous Zhou in their energy conservation work. Statistics to the end of the year show that the entire zhou saved 1,315 tons of coal and nearly 700 tons of petroleum, exceeding conservation plans by 87.8 and 33.6 percent respectively.

Based on the principle of agricultural priorities, this autonomous zhou in its supply of petroleum last year guaranteed those that should have been guaranteed and tightened the supply of those that should have been tightened and reduced with determination the irrational use of oil. Through investigative analysis and classification of the more than 800 organizational units which the zhou's oil stations supply oil, rational oil supply and conservation of consumption of guaranteeing the important and taking care of the general were achieved. Liaison personnel were used to regularly visit transportation departments to understand situations in vehicle changes and oil consumption and to insist on supplying oil according to actual needs. Zhou and county fuel companies also positively implemented the work of waste oil return and utilization. In Yongjing County alone, 65 tons of lubricant oil were extracted from returned waste oil. In the supply of coal, the activities of "san sao" and "si fang" ["four preventions"] (prevention of spontaneous combustion, deterioration, wind waste, and water flooding) were implemented on a priority basis. Over 300 tons of coal were saved by using "san sao" in the zhou. In the processing of coal

briquets on a bed of coal dust with placing them on a bed of cinders and saved over 500 tons of coal dust. Last year, the zhou fuel company also transferred more than 15,000 yuan as assistance funds for the modification of furnaces and stoves. In the two counties of Hezheng and Yongjing alone, assistance was extended to over 4,130 commune member households to carry out furnace and stove modification.

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END